SCIENCE ABSTRACTS.

Section A.—PHYSICS

MAY 1911.

GENERAL PHYSICS.

567. *Anschütz Gyro-compass.* **G. K. B. Elphinstone.** (Phys. Soc., Proc. 28. pp. 201–208; Discussion, p. 208, April 15, 1911. Abstract. Electrician, 66. pp. 961–962; Discussion, p. 962, March 24, 1911.)—The instrument consists of a rapidly rotating, electrically driven, wheel enclosed in a casing which is so suspended that the centre of gravity of the suspended system is considerably below the point of suspension, and therefore acted on by gravity like a pendulum. With the axle of the gyro in any direction except parallel to the meridian, the gyrostatic action of the wheel tends to maintain the plane of rotation fixed in space irrespective of the rotation of the earth, and, in consequence, a dipping down of one end of the axle, and an upper inclination of the other end takes place. The force of gravity exercises a couple tending to restore the axle to the horizontal position, and a precession results which turns the axle towards the meridian, this precession being reversed should the axle once more reach the horizontal position after it has crossed the meridian. A natural tendency of a gyrostat suspended in a frame as above, provided the method of suspension introduced very little friction, would be to swing from side to side of the meridian for a long period of time. On this account a method of damping these swings without the use of friction is required. This is obtained by making use of the current of air set in motion by the rapidly revolving wheel. This current of air is led out through a horizontal tube at the lowest part of the gyro casing and tangential to its periphery; the air-blast acts horizontally. A small adjustable weight is attached to the gyro spindle to enable the apparatus to be used in different latitudes. A. D. R.

568. *Experiments on Fatigue of Metals.* **J. H. Smith.** (Iron and Steel Inst., Journ. 2. pp. 246–314; Discussion, pp. 315–318, 1910. Mech. Eng. 26. pp. 599–604, Nov. 11, and pp. 648–648, Nov. 18, 1910. Metallurgie, 8. pp. 140–152, March 8, 1911.)—The paper gives an account of experiments made by the author with his machine, designed with object of producing alternating tension and compression stresses. In order to define clearly the materials employed in the alternating stress tests, the usual measurements were made by static test. Results of these, together with the analyses, are given. The limits of proportionality in tension were measured, as were yield-points, max. stresses, breaking stresses, percentage extensions and percentage contractions. The limits of proportionality in tension and compression were in many cases also measured in the fatigue tester; hardness (Brinell ball) tests were also made. These results are all recorded in the tables. A fact, not commented upon but curious, is that the yield-point is, roughly, always 30 per cent. above the P_1 limit. The primary object of the endurance tests was the determination, for the various steels, of the ranges of stress which correspond to rupture with one million repetitions when fluctuating at a constant rate of 1000 alternations per min. Experiments were made with various shaped specimens. The results showed the importance of a truly uniform shape for the curved ends of specimen. It is suggested that the irregularities met with in endurance tests are due to neglecting this important point. In all cases where rupture occurred the changes were noted. Just before rupture the material appears to become softer, a yield occurs, and rupture follows. The character of the breakdown appears to be the same, whether rupture takes place after a few alternations or after a great many. Breakdown seems to extend over the whole specimen, and not, as is believed by some, at only one point. The following general conclusions are drawn from the experiments: (1) That if a material be subjected to stress alternations of high periodicity and of fixed range, and compressive or tensile mean stress be gradually applied, a yielding condition will be found at a definite value of the applied mean stress. (2) That the yield is tensile if the mean stress is tensile, and is compressive if the mean stress is compressive. (3) That for equal and opposite mean stresses the magnitude of the yield range is the same. (4) That the Wöhler limiting range for any material is a yield range. (5) That a series of yield ranges may be determined for most materials, by experiment on a single specimen, without damaging the specimen. C. A. M. S.

569. *Behaviour of Soft Mild Steel beyond the Proportionality Limit.* **H. Cassebaum.** (Ann. d. Physik, 34. 1. pp. 106–130, Dec. 30, 1910. Extract of Dissertation, Göttingen.)—The paper sets out the results of a number of tests to determine the relation of the extension of mild steel after overstraining with the time which has elapsed. Experiments were made in which the load was kept constant after overstraining and in which it was allowed to fall, and *vice versâ*. It is found that, for the material tested, the rate of extension at any point in the range is independent of whether that point is passed with rising or falling load. Points of the same speed of extension lie on a group of curves which are bounded by the curve of "infinitely slow extension," *i.e.*, of zero velocity. The rate of extension is an exponential function of the extension, so that equidistant velocity curves are passed with speeds which are in geometrical progression. This law does not hold good in the neighbourhood of the curve of zero velocity. By being allowed periods of rest in a loaded or unloaded condition the specimens gave velocity curves with inflections upwards, so that they could withstand a further range of loading. This hardening depends on the time, but the load only is increased, not the ultimate extension. The results are numerical, and apply only to the particular state tested, but they give an indication of the lines on which further experiments may be carried out. C. A. M. S.

570. *Behaviour of Steel under Combined Static Stress and Shock.* **F. Rogers.** (Phys. Soc., Proc. 23. pp. 39–48; Discussion, p. 48, Dec., 1910.)—The paper discusses impact machines of the pendulum class and rotating disc type and the falling-weight machines of Hatt and Stanton and Bairstow. Although the latter eliminate bending stresses, the actual determination of stresses is considered impracticable. Attention is drawn to the importance of the time rate of increase of stress, ds/dt, in the behaviour of materials under stress. The exact determination of this rate must usually present much difficulty, but the indirect experimental method adopted consisted in submitting specimens of steel to shock whilst under static loading. The machine used for this purpose was exhibited. The important conclusion that steel is substantially less resistant to shock whilst it is under static stress appears to be definitely established by these experiments. In some cases the effect of a large static stress was to diminish the resistance to shock by as much as 80 per cent. In the *discussion* which followed, **R. S. Whipple** asked if the same results were obtained with high- and low-carbon steels, and whether the results were affected by annealing. **H. Etchells** asked what the author meant by "calculated extreme static stress," and also how the stress was applied. It was difficult to calculate the stress in the author's experiments. **C. A. M. Smith** said the paper opened up a field for research, and then described some experiments which he had been making recently on the time rate of change of strain. The **Author**, in reply to Whipple, said he had obtained the same results from steels with carbon varying from 0·16 to 0·45 per cent. The manner in which the stress was applied was shown.

C. A. M. S.

571. *Flowing Pressure of Tin at High Temperatures.* **E. Jänecke.** (Metallurgie, 8. pp. 68–72, Feb. 8, 1911.)—Flowing pressure has recently been added to the properties characterising materials since it has been shown [see Abstract No. 2794 (1909)] that an exact parallel exists between hardness and flowing pressure. The author has examined this property of tin with the object of obtaining more exact information on the temperature at which rhombic tin changes into the tetragonal modification. Tin was forced through a circular steel die in an apparatus which could be heated electrically, and the lowest pressure causing a steady flow (about 8 mm. per hour) was determined at the various temperatures. The influence of the rate of cooling on the flowing pressure was found to be considerable, and only very slowly cooled material was used in the experiments, the elastic modulus of the material being calculated to 887 kg./mm.^{2} as compared with 4149 for drawn wires. Plotted in the form of flowing pressure-temperature diagrams the results show a linear relationship with no discontinuities in the curve indicating that under pressure the change is subject to a considerable amount of lag.

F. C. A. H. L.

572. *Extensibility of Vulcanised Indiarubber.* **Chéneveau** and **Heim.** (Comptes Rendus, 152. pp. 320–322, Feb. 6, 1911.)—The experiments described prove the law $y = kx + a \sin^2 bx$, where k and a are constants characteristic of the initial and mean elongations, y is the extension in cm., x is the load in kg., b is characteristic of the ultimate elongation. It is found that k and a are higher for better qualities of rubber, and may therefore serve as a scale for the numerical classification of different qualities of rubber. It is, however, noted that k, a, and b only assume steady values after the third application of load to a specimen. The law of extensibility holds good up to the

breaking load X, the extension being then Y. It is found that *b*X increases as the quality of rubber deteriorates. The consideration of this constant allows the rubbers to be classified in the same order as that indicated by *k* and *a*; it follows that the elongation Y diminishes constantly as we pass from good to inferior rubbers. The constants *k*, *a*, and *b*X serve completely to classify a rubber, and can be used in conjunction with comparative tests with varying degrees of vulcanisation to determine the vulcanisation required by each deposit of crude gum, and the value of rubber this gum will give. These researches throw some light on the molecular composition of the rubber. The curve of extension consists of three parts characteristic of the initial, mean, and ultimate elongations respectively. The initial extension is due to the yielding of a soft outside skin which extends readily under light loads; the mean extension is the result of simultaneous but unequal elongations of the soft envelope and of a hard core under the influence of higher loads; the ultimate stretch is due to the final yielding of the hard core under extreme stress. C. A. M. S.

573. *Influence of Viscosity on the Stability of Flow of Fluids.* **A. Mallock.** (Roy. Soc., Proc. Ser. A. 84. pp. 482–491, Jan. 26, 1911.)—Although it is impossible by mathematical analysis to follow in detail the motion in an unstable flow, the general character may, in many cases, be traced, and the object of the present paper is to apply an observation made by Froude to the explanation of some of the commonly occurring phenomena of instability. At the British Association meeting at Bristol in 1875, Froude showed an experiment in which a jet of water impinged symmetrically on a similar aperture in a vessel standing near the first. The water in the first vessel (A) was maintained at a uniform level, and by providing an outflow in the second vessel (B) at a slightly lower level the stream from one to the other could be maintained indefinitely, nearly the whole of the outflow from A entering B at the speed due to the head. A small but definite loss of fluid, however, occurred at the entrance to the aperture in B, and this loss is confined to a thin layer at the outer surface of the jet—to that part of the jet, in fact, which was in contact with, or close to the walls of the passage from which it issued; Froude pointed out that this was to be explained by the loss of velocity suffered by the outer part of the jet from surface friction and viscosity, for the fluid which has had its velocity lowered without having its pressure raised has lost potential, and is therefore incapable of entering a region where the pressure is greater than that due to its diminished velocity. Various problems are discussed, and explanations of the observed effects are given based on the above principle; among these problems may be noted: (i) The continuance of tidal flow in many tidal waters after the tide has turned inshore; (ii) vortex motion in a vessel with a circular hole in floor; (iii) the initiation of eddies in a stream flowing past an obstacle, various shapes of such obstacles being dealt with and application being made to the Æolian harp and allied phenomena. A. W.

574. *Turbulent Viscosity of Liquids.* **E. Bose** and **M. [Margrete] Bose.** (Phys. Zeitschr. 12. pp. 126–135, Feb. 15, 1911. Communication from the Phys. Inst. of the Nat. Univ., La Plata, Argentine.)—A continuation of previous work showing the difference between the viscosities in the Poiseuille condition and in the turbulent condition which is attained under higher pressures. The results of the research are exhibited in a number of tables and culminate in the calculation of the Osborne Reynolds criterion for

the liquids dealt with, viz., water, ethyl alcohol, ethyl acetate, benzol, toluol, acetone, chloroform, bromoform, and mercury. The values in question are respectively 1, 0·792, 0·887, 0·918, 0·901, 0·829, 1·08, 1·11, and 0·916, with mean value of 0·919 ± 0·188. [See Abstracts Nos. 1858 (1909) and 676 (1911).]

E. H. B.

575. *Cinematograph Study of the Displacement of Smoke Particles produced by very Rapid Air-waves.* **V. Henri and S. Lifchitz.** (Comptes Rendus, 152. pp. 953–955, April 3, 1911.)—A study is made of the displacements of the particles of smoke, contained in a vessel, by high-frequency air-waves. An ultramicroscope and a kinematograph film are employed. It is proved that the phenomena are purely mechanical, the disturbances being produced by waves passing through the air. The phenomena are independent of the electric charge of the particles. Under the influence of the air-waves particles distant only about 20 μ from one another are sometimes moving in opposite directions at the same instant. It is deduced that with very high-frequency air-waves vortex filaments of very small radius are formed. The action produced by these filaments would explain the phenomena. A. R.

576. *New Method of Producing Ripples. Optical Analogies.* **A. H. Pfund.** (Phys. Rev. 32. pp. 324–327, March, 1911.)—The chief point claimed for these experiments is their simplicity. The current from the secondary of a small transformer (2000 volts, 60 ∿) passes through a helium vacuum tube, then through a wire A, 0·5 mm. in diam., into distilled water contained in a hard rubber tray, and finally back through a wire (B) to the transformer. The wire B dips deeply into the water, while the wire A only just touches the surface, and it is at this point that the ripples are produced. Each pulsation of the current produces a ripple which moves out from its source with so great a velocity that, in continuous illumination, the surface of the water appears undisturbed. However, by making the illumination intermittent, *i.e.*, synchronous with the rate of production of ripples (which is accomplished by the use of the helium vacuum tube), the ripples stand still and may be observed at leisure. For observing or photographing ripple phenomena a lens is placed so that the helium tube and the eye or camera are at conjugate foci. In order to obtain light from a "point" source, all light coming from the helium tube with the exception of that from 1 mm. of the capillary is screened off. Photographs of some of the results so obtained are given. A. E. G.

577. *Motion of a Sphere in a Viscous Medium along a Plane Boundary.* **J. Stock.** (Acad. Sci. Cracovie, Bull. 1a. pp. 18–27, Jan., 1911.)—A mathematical discussion resulting in the conclusions that (1) a sphere moving slowly in a viscous medium and parallel to a plane boundary experiences a resistance in the direction of the motion, increased in a certain ratio by the presence of the wall; (2) perpendicular to the wall there is no force while *udu/dx*, &c., are negligible; (3) there is no couple on the sphere. E. H. B.

578. *Resistance to the Movement of Small Non-spherical Bodies in a Liquid.* **J. Boselli.** (Comptes Rendus, 152. pp. 133–136, Jan. 16, 1911.)—The non-spherical bodies examined consisted of red blood globules from a rabbit and a fowl, the former consisting of circular discs with no swelling in the centre, the latter of elliptical discs with a central swelling. The rate of fall is studied of the globules suspended in isotonic solutions of sodium chloride and sugar contained in vertical tubes 0·15 cm. in diam., and maintained at 30·8° C. Assuming that the resistance is proportional to the viscosity of the liquid, $Vg(D - D_1) = \eta w A$, where V is the volume of the globule, D its specific gravity, D_1 the specific gravity of the liquid, η its viscosity, w the velocity of the globule, and A a constant. From this relation the value of A for rabbit's blood in NaCl solution is $2{\cdot}92 \times 10^{-3}$ and in sugar solution 3×10^{-3}, and for fowl's blood in NaCl solution $3{\cdot}6 \times 10^{-3}$. The mean diam. of the circular discs of rabbit's blood is $7{\cdot}08 \times 10^{-4}$, and the mean of the large and small diams. of the elliptic discs of fowl's blood is $9{\cdot}3 \times 10^{-4}$, so that the ratio of the mean diams. is $9{\cdot}3/7{\cdot}08 = 1{\cdot}31$, and of the values of A, $3{\cdot}6/3 = 1{\cdot}2$; hence it is considered permissible to regard the value of A as proportional to the diam. of the disc; just as in the case of a sphere, the rate of fall is proportional to the radius. W. H. St.

579. *Maintenance of Periodic Motion by Solid Friction.* **A. Stephenson.** (Phil. Mag. 21. pp. 161–165, Jan., 1911.)—The maintenance of periodic motion by solid friction demonstrates that such friction diminishes as the velocity increases through a small range at least. However the friction may vary, there is always a position of equilibrium, and the small motion about it is evidently of the type $\ddot{x} + (\kappa - \lambda)\dot{x} + n^2x = 0$, where λ is a positive quantity proportional to the velocity-rate of change of the frictional force at the value corresponding to the relative velocity in equilibrium, v say. The position of equilibrium is therefore unstable if λ is greater than κ, and any slight disturbance is secularly magnified in free period. A discussion of the equation then follows, some of the known features of the motion of bowed strings being obtained. E. H. B.

580. *Property of the Asymmetric System.* **A. Stephenson.** (Phil. Mag. 21. p. 166, Jan., 1911.)—If an asymmetric system is subject to a direct periodic force the equation of motion is of the form $\ddot{x} + \kappa n\dot{x} + n^2(1 + x/a)x = bq^2 \cos qt$. If a is finite, b and κ small, the steady motion is $x = b[q^2/(n^2 - q^2)] \cos(qt + \eta)$, when terms of the second order are neglected. This motion may, however, be unstable if q approximates to $2n$, as is then shown mathematically. Thus, the asymmetric system is sensitive to direct periodic force of double the natural frequency and of intensity exceeding a certain limit proportional to the motional resistance. If asymmetric oscillations exist within the molecule there would follow the possibility of monochromatic fluorescence with a frequency of emission half that of the incidence. E. H. B.

581. *Constants of Inert Gases.* **C. Cuthbertson.** (Phil. Mag. 21. pp. 69–77, Jan., 1911.)—Recently G. Rudorf calculated some of the molecular constants of the inactive gases to see how far the values obtained by various methods agreed among themselves. Since then other papers on the physical properties of these gases have provided additional data for their study, and a comparison of these figures, obtained by different methods, here leads to some interesting conclusions. These are shown in tables and in graphs, all the latter being nearly straight lines. They may be approximately represented by the following linear relations: $N \propto SP$, $N^2 \propto \sigma$, $N^2 \propto T$, $T_c \propto \sigma$; where N is the number of dispersion electrons, P the length of the mean free path, σ the radii of the spheres of molecular action, T the absolute temperature, and T_c the critical temperature. The gases taken into account are He, Ne, A, Kr, Xe. In some respects oxygen and nitrogen would almost fall into line with the above, but hydrogen would not. The results throw

additional light on Rankine's discovery that the constant in Sutherland's formula for the temperature coefficient of viscosity is allied to the critical temperature. [See Abstracts Nos. 1249 (1909), 888, 1387, and 1727 (1910).]

E. H. B.

582. *Tension of recently-formed Water-surface.* **N. Bohr** (Roy. Soc., Proc. Ser. A. 84. pp. 395–408, Dec. 15, 1910.)—A discussion as to the cause of the difference between the values for surface tension of water found by the author for the Rayleigh jet-vibration method [see Abstract No. 1176 (1909)] and by P. Lenard by the vibration of falling drops (Heidelberger Akad. Wiss., Sitzungsber. Math.-nat. Kl., No. 18, 1910). The cause of the great deviation between the results of the method of drop-vibration and those found by the method of jet-vibration should, in the present author's view, be sought in the circumstance that sufficient regard as to the influence of irregularities of mechanical character, arising from the disengagement of the drops, is scarcely paid by the drop method. The investigation of the influence of such irregularities seems very difficult for drops, but the corresponding task is facilitated in the case of jets by the perfectly steady character of the phenomena.

E. H. B.

583. *Formation of Spheres of Liquids.* **C. R. Darling.** (Nature, 85. p. 512, Feb. 16, 1911.)—A simple method of performing Plateau's experiment is described. A glass beaker about 10 cm. diam. and 15 cm. high is filled with water at 22° C. to two-thirds of its height. By means of a pipette 100 c.cm. of a solution of 80 gm. of common salt in 1 litre of water are discharged at the bottom of the beaker, forming a lower, slightly denser, layer. A large funnel with a tap and a stem 1 cm. or more in diam. is then placed centrally in the beaker so that the stem terminates about 7 cm. from the bottom of the vessel. When a quantity of commercial orthotoluidine at a temperature less than 22° C. is allowed to flow through the funnel into the water a sphere of orthotoluidine forms on the end of the stem. It is easy thus to make spheres 6 or 8 cm. in diam. which are clearly visible on account of the red colour of the liquid.

J. J. S.

584. *Experimental Investigations of the Surface Tension at the Interface Solid-liquid.* **K. Tangl.** (Ann. d. Physik, 34. 2. pp. 311–342, Feb. 3, 1911.)—By a method related to that of Röntgen the author has determined the difference of surface tension between caoutchouc-water and caoutchouc-moist air, and also paraffin-water and paraffin-moist air. In the former case this difference for thin-walled tubes, imperfectly wetted by water, was less than for the surface tension of water, whereas with thick-walled tubes which were wet with water, the value was greater, about 10·5. In the case of paraffin the surface tension is positive, in accordance with the fact that paraffin is not wetted by water. The author has also determined the coefficient of diffusion of water in caoutchouc. These diffusion experiments point to the formation of a surface layer when caoutchouc comes in contact with water-vapour, and which is connected with tension-changes in the layer. It is also to be concluded from the experiments that there is a time change in the surface tension caoutchouc-water.

A. F.

585. *Surface Tension of Liquid Sulphur.* **W. A. D. Rudge.** (Cambridge Phil. Soc., Proc. 16. pp. 55–63, Feb. 15, 1911.)—If a small crystal of sulphur is heated on a glass slip it melts at 115° and gathers itself into a drop which does not wet the glass. When such drops were allowed to solidify the shape did not perceptibly alter, the contact between the drop and the glass being sharply defined. On raising the temperature the shape of the drop did not alter until 185° was reached, when it flattened, and remained in this condition until 256°, when it flattened still further. On cooling down from 265°, however, the shape of the drop does not alter. By heating to the higher temperatures the sulphur "wets" the glass, and on cooling still sticks; but if the solidified sulphur is brought on to a fresh piece of the glass and again melted it does not wet the glass. A series of measurements of the angle between the tangent to the surface of the drop at the point of contact and the glass plate was taken, and this was found to vary from about 60° at 180° C. to about 26·5° at 260° C. The surface tension was determined from the rise of the liquid in a capillary tube, and was found to be about 11·56 dynes/cm. The angle of contact between fused sulphur and glass was found to be about 60°. A. F

586. *A Theory of Synoptic Pressure Changes.* **F. M. Exner.** (Akad. Wiss. Wien, Sitz. Ber. 119. 2a. pp. 697–738, May, 1910.)—In previous communications the author has discussed the relation of pressure-changes at the earth's surface with the horizontal adiabatic motion of air masses of different temperatures [Abstracts Nos. 878 (1907), 17 (1908)]. In the present paper this idea is carried further by imagining the atmosphere divided into horizontal layers. In the first part a differential equation is developed from Guldberg and Mohn's equation and the ordinary thermodynamic relations from which the rate of variation of pressure can be calculated (with certain assumptions and restrictions) from a given distribution of temperature and pressure. In the second part this equation is applied to a schematic cyclone, the arrangement of which is based as far as possible on the results of observations of the upper air as generalised by Wagner. The system is supposed to be 2000 km. in diam., the isobars are concentric circles, and the pressure ranges from 740 mm. at the centre to 760 mm. at the periphery. The distribution of temperature is made to correspond with general conditions. Values range from 8° C. in the north-west quadrant to 18° C. in the south and south-east. For the sake of simplicity a vertical temperature gradient of 0·6° C. per 100 m. is assumed for all parts of the system up to the level of the isothermal layer. In the isothermal the temperature gradient is linear. A uniform pressure of 40·5 mm. and a uniform temperature of —55° C. is supposed to prevail in all parts of the system at a height of 20 km. Tables are given showing for such a system the temperature and pressure at each km. for selected positions in the system. These are then introduced into the equation, and the part which each layer takes in determining the rate of change of pressure is determined from them for selected positions. It appears that in the eastern and southern quadrants of the depression the density in the layers from 0 to 8 km., and consequently the fraction which this air contributes to the total pressure at the surface, is decreasing rapidly. From 8 to 10 km. the rate of decrease of density is greatly increased, reaching a maximum at about 10 km. From 12 to 20 km. there is hardly any change of density, showing that this air takes practically no part in producing changes of pressure at the surface. In the northern and western quadrants things are quite different. Density is increasing rapidly up to 8 km. Above this level the rate slackens rapidly, and from about 10 km. to 20 km. there is a slight decrease of density, showing that these layers are producing a small decrease of pressure at the surface, which is, however, far counterbalanced by the rapid increase due to the increase of density of the lower layers. In the

centre of the system the layers up to 8 km. take no part in producing changes of pressure at the surface. Above this level we have first a rapid decrease of density up to about 11 km., and then an increase which continues up to the 20-km. level. Thus the rise of pressure occurring at the surface near the centre of the system is due to increase of density in the layers above 11 km. R. G. K. L.

587. *Temperature Seiche.* **E. M. Wedderburn** and **A. M. Williams.** (Roy. Soc. Edinburgh, Trans. 47. 22. pp. 619–642, 1911.)—Observations made in the Madüsee, in Pomerania, have demonstrated the existence of a temperature seiche, the period of which agrees very well with the computed period, and which has an amplitude of about 10 m., *i.e.*, about one-quarter of the depth of the lake. This amplitude is relatively to depth about the same as that of the Loch Ness temperature seiches, which have an amplitude of from 150 to 200 ft. Apparent irregularities in the temperature-seiche oscillations are explained on the assumption of the interference of progressive waves, and from experimental observations it appears likely that waves are propagated at the discontinuity layer whenever there is a change in the direction or in the force of the wind. The paper gives the hydrodynamical theory of temperature oscillations in lakes, and the calculation of the period of the temperature seiche in the Madüsee. It concludes with an account of certain laboratory experiments which were carried out to verify the hydrodynamical theory. A. D. R.

588. *Disposition of the Earth's Crust in German East Africa.* **E. Kohlschütter.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 1–40, 1911.)—This preliminary paper discusses gravity pendulum observations which have been conducted in German East Africa with a view to testing how far conditions of isostasy are fulfilled. It is found that if we deduce from the actual observed values of *g* those values which would correspond to points at the same latitude and longitude and at the mean sea-level, the resultant values vary considerably from normal. Those calculated from stations on the higher plateaus are on the average 0·004 cm. per sec. per sec. greater than normal; those from stations on moderately high ground are 0·007 cm. per sec. per sec. above normal; while those derived from stations on low-lying ground are 0·020 cm. per sec. per sec. below normal. The observations and the methods of reduction are given in detail. A. D. R.

REFERENCES.

589. *The Elastica.* **W. E. Lilly.** (Engineering, 91. pp. 401–402, March 31, 1911.)—The author states it has long been known that Euler's formula, although nearly true for long columns, gives false results when applied to columns of medium and short lengths, with the result that various formulæ, more or less empirical, have come into use for the design of such columns. The Eulerian analysis of the elastica is discussed, more especially with regard to shearing stresses. It is proved mathematically that the curve of a bent spring can be produced by a different system of loading than was contemplated by Euler. C. A. M. S.

590. *Erosion of Gun Tubes and Heat Phenomena in the Bore of a Gun.* **H. J. Jones.** (Engineer, 111. pp. 294–295, March 24; 317, March 31; 360–362, April 7; 380–381, April 14, and pp. 399–400, April 21, 1911.)—The question of heat-transfer is dealt with at length, and the effect of temperature upon the skin of the rifling. L. H. W.

591. *Optical Planimeter.* **J. Schnöckel.** (Zeitschr. Instrumentenk. 31, pp. 65–72, March, 1911.)—Describes an optical planimeter suitable for determining mean ordinates and areas of diagrams. With curves 30 to 40 cm. in width the mean ordinate can be found with little trouble correct to 0·1 mm. Diagrams of the instrument, which apart from the optical arrangement is similar to the Prytz hatchet planimeter, are given, as is also the theory of the method of use. A brief abstract cannot be given. A. W.

592. *Elastic Breakdown of Certain Steels.* **C. A. M. Smith.** (Iron and Steel Inst., Journ. 1. pp. 431–466, 1910. Mech. Eng. 26. pp. 44–47, July 8, and pp. 107–111, July 22, 1910.)—A *résumé* of the author's previous work on the subject is given [see Abstracts Nos. 217, 875 (1910) and 4, 298 (1911)], and the researches on the time-effect and slipping in mild and alloy steels have been continued. Applying Guest's shear stress law to thick cylinders the author shows the importance of taking shear stress into consideration in the case of a 12-in. gun, diagrams of the distribution of stress, both before, and at the moment of explosion, being given. F. C. A. H. L.

593. *Stationary Motions of Continuous Media.* **K. Żorawski.** (Acad. Sci. Cracovie, Bull. 1a. pp. 1–17, Jan., 1911.)—A mathematical discussion of phenomena in *n*-fold space. E. H. B.

594. *Interaction of Spheres Moving in a Viscous Fluid.* **M. Smoluchowski.** (Acad. Sci. Cracovie, Bull. 1a. pp. 28–39, Jan., 1911.)—Treats mathematically the case of two spheres, then of *n* spheres, and afterwards passes to a special discussion as to the legitimacy of applying Stokes' formula to the terminal velocity of the particles in a cloud, as to which grave doubts are felt. E. H. B.

595. *Coupled Vibrations.* **A. Kalähne.** (Phys. Zeitschr. 11. pp. 1196–1209, Dec. 15, 1910.)—This mathematical article deals with the subject of coupled vibrations as a special case of Lagrange's equations of motion of a mechanical system, using the principal or *normal* co-ordinates. But at the conclusion the results are not very tractable—thus for two degrees of freedom the equation is a biquadratic. E. H. B.

596. *Translatory Motion of a Fluid Sphere in a Viscous Medium.* **W. Rybczyński.** (Acad. Sci. Cracovie, Bull. 1a. pp. 40–46, Jan., 1911.)—Obtains mathematically and exhibits in a diagram the stream-lines inside and outside the sphere. E. H. B.

597. *Optical Systems and Earth's Motion.* **G. Sagnac.** (Le Radium, 8. pp. 1–8, Jan., 1911. Comptes Rendus, 152. pp. 310–313, Feb. 6; Errata, p. 480, Feb. 20, 1911.)—Discusses the possible entrainment of the ether and possible eddy motions and their superior limit in the vicinity of the earth. E. H. B.

598. *Mechanical View of Electromagnetic Phenomena.* **A. Korn.** (Deutsch. Phys. Gesell., Verh. 13. 6. pp. 249–256, March 30, 1911. Comptes Rendus, 152. pp. 306–309, Feb. 6, 1911.)—On the basis of C. A. Bjerknes' pulsating spheres which, in a fluid, attract or repel according to the natural law, the author here builds up a mechanical conception of electromagnetic phenomena, which occupies an intermediate position between the Maxwell-Hertz theory and the electron theory. It also satisfies the relativity principle. E. H. B.

599. *Vibrations of Circular Plate and their Relation to Bessel Functions.* **J. R. Airey.** (Phys. Soc., Proc. 23. pp. 225–232, April, 1911.)—Mathematical.

600. *On Atmospheric Oscillations.* **H. Lamb.** (Roy. Soc., Proc. Ser. A. 84. pp. 551–572, Feb. 15, 1911.)—The question discussed is that of the free oscillations of an atmosphere whose temperature varies with the altitude. The problem is treated mathematically as a two-dimensional one. L. H. W.

LIGHT.

601. ***Absorption and Reflection of Infra-red Rays by Quartz, Tourmaline, and Diamond.*** **O. Reinkober.** (Ann. d. Physik, 34. 2. pp. 343–372, Feb. 8, 1911. Extract from Dissertation, Berlin.)—The dependence of reflection on the direction of vibration of the incident light was investigated for crystalline quartz and tourmaline. An investigation was also made of the reflecting and absorbing power of amorphous quartz and diamond. The region investigated extended from wave-length 1 μ to 15 or 18 μ. Similar investigations, for calc-spar and aragonite, have been made by Nyswander, who found that some reflection maxima belong only to the ray vibrating parallel, others only to the ray vibrating perpendicular, to the axis of the crystal [see Abstract No. 1027 (1909)]. A special linear vacuum thermopile, of ten times the usual sensitiveness, was constructed from iron and constantan wire 21 μ thick. It enabled a less sensitive galvanometer to be employed, so lessening trouble from local magnetic disturbances. In vacuum the thermopile was about half as sensitive as a bolometer with which it was compared. Crystalline quartz exhibits dichroism most plainly in the region of metallic reflection 12 μ to 13 μ. Of two very sharp reflection bands here; one, at 12·52 μ, belongs only to the ordinary ray; the other, at 12·87 μ, only to the extraordinary ray. The extraordinary ray has also a special maximum at 8·70 μ. In general the reflection curve shows many hitherto unobserved complexities. Quartz glass shows a relatively simple reflection spectrum in comparison to crystalline quartz. The sharp reflection bands are replaced by broad diffused ones, and the complicated reflection region between 8 μ and 9 μ is represented by one wide band. There is, naturally, no dichroism with amorphous quartz. The author's observations and those of Coblentz are not in agreement. The transparency of quartz glass is 90 per cent. from 1 μ to 4 μ; from 5 μ to 8 μ it falls off rapidly, with two small maxima about half-way; from 8 to 10 μ, and from 12 to 18 μ, the transparency is very low indeed, under 5 per cent., but there is a well-marked maximum at 11 μ. Reflection measures of tourmaline were made on a dark green plate 7 mm. thick, cut parallel to the axis. The incident radiation was linearly polarised by reflection at a selenium mirror. The reflection curves of tourmaline for the ordinary and extraordinary rays, from 1 μ to 15 μ, show considerable divergence, and intersect in places. The curve for natural light follows a mean course between the two, as it should. The dichroism becomes much stronger beyond 7 μ. Some previous measures by Coblentz, with natural light, of reflection bands are in fair agreement with the author's. The extraordinary ray, for tourmaline, shows weak anomalous reflection at 2·95 μ (among other places), and on examining the transparency of a thin 0·1 mm. plate it was found that the transparency at 2·9 μ was zero for the extraordinary ray, but 80 per cent. for the ordinary ray. The reflecting power of a large diamond was examined from 1 to 19 μ, and found to be constant (16·5 per cent.), as in the case of selenium in the infra-red. Absorption measures were made on a diamond plate 1·28 mm. thick. In general the plate shows high transparency, 60–70 per cent., for the heat rays, except for a wide, complex absorption band from 2·6 to 6·5 μ. There is also a weak minimum of transparency at 14·1 μ.

A. E.

602. *Reflective Power of Lamp- and Platinum-black.* **T. Royds.** (Phil. Mag. 21. pp. 167–172, Jan., 1911.)—The method employed in the research consisted in measuring the galvanometer deflections, first when rays fall directly on a thermopile, and then when they fall on the lamp- or platinum-black, the rays diffusely reflected from it being focussed on a thermopile by means of a polished hemisphere of German silver. The black surface was attached alongside the thermopile slit, which was situated immediately in front of the exposed junctions. An external concave mirror cast, through a narrow opening cut in the hemisphere, an image of an illuminated slit on to the thermopile when placed a little to the left of the centre of the hemisphere. If the thermopile together with the black surface was now displaced relative to the hemisphere until the thermopile was as much to the right of the centre, the slit image would then fall on the black surface and the reflected light would be focussed on the thermopile. The galvanometer deflections in these two positions of the thermopile would measure the intensities of the incident and reflected radiation respectively. The reflective power was determined for the following radiations whose maxima lie in the infra-red: (i) Radiation from an incandescent mantle transmitted by a layer of water 1 cm. thick (maximum about 0·8 μ). (ii) Reststrahlen from selenite (maximum at 8·7 μ). (iii) Reststrahlen from fluorspar (maximum at 25·5 μ). (iv) Reststrahlen from rock-salt (maximum about 51 μ). After applying various corrections, the final results obtained were as follows:—

Wave-length.	Lamp-black. 0·205 mm. thick.	Platinum-black.	
		Deposited 15 min.	Deposited 3 min.
	Per cent.	Per cent.	Per cent.
0·8 μ	1·18	0·17	1·80
8·7 μ	0·66	0·59	5·70
25·5 μ	0·67	0·93	7·08
51 μ [1]	1·4	0·79	6·8
51 μ [2]	1·6	1·1	7·4

[1] Rock-salt Reststrahlen using metal shutter.

[2] Ditto using rock-salt shutter.

Fery [Abstract No. 2081 (1909)] concluded that as much as 18 per cent. of the radiation from a black body at 100° C. was reflected from a platinum-black surface, and approximately the same amount from a lamp-black surface. Kurlbaum's determinations of Stefan's constant were not corrected for the reflective power of platinum-black. The radiation from a black body at 100° C. has its maximum about $\lambda = 8\,\mu$, where the reflective power has been found to be 0·59 per cent. Hence Kurlbaum's value $7{\cdot}061 \times 10^{-15}$ becomes $7{\cdot}10 \times 10^{-15}$. Planck's value for the elementary quantity of electricity is consequently increased in the same ratio, and becomes, taking Paschen's value for b, $4{\cdot}624 \times 10^{-10}$ e.s. unit. A reflective power of 1·0 per cent. would bring it to $4{\cdot}65 \times 10^{-10}$, Rutherford and Geiger's experimental value. A. W.

603. *Variation of Refractive Index with Temperature in the Infra-red Region for Rock-salt, Sylvin, and Fluorite.* **E. Liebreich.** (Deutsch. Phys. Gesell., Verh. 13. 1. pp. 1–18, Jan. 15, 1911.)—The temperature-coefficient of the index was investigated as far as 6·5 μ for fluorspar, and 9 μ for sylvin and rock-salt (in some cases 21 μ). The coefficient is negative, as in the visible region, but its absolute amount increases much more slowly with wave-length than in the visible region. Change of density due to temperature is not sufficient to explain the diminution, which is ascribed to the influence of the infrared absorption region. It may be that heating causes the absorption bands to shift in the direction of greater wave-length; or it may affect their form, so that they become less sharp at higher temperatures. The first alternative, a shift, is the more probable. Possibly both shift and change of form may occur. **A. E.**

604. *Long-waved Reststrahlen of Calc-spar.* **H. Rubens.** (Deutsch. Phys. Gesell., Verh. 13. 2. pp. 102–110, Jan. 30, 1911.)—The high reflecting power of calc-spar for heat rays of great wave-length justifies the presumption that this substance should show metallic reflection in the spectral region near 100 μ. The author investigated the question by a method combining the method of Reststrahlen with that described by R. W. Wood and Rubens [see Abstract No. 220 (1911)], the Reststrahlen after reflection from two calc-spar mirrors being passed through the new quartz lens apparatus. The result was a very pure and comparatively bright pencil of Reststrahlen. Comparison of the micro-radiometer indications thus obtained, with those given by the quartz lenses alone without the calc-spar mirrors, show that the radiation undergoes decided selective weakening by the two-fold reflection at the calc-spar surfaces, and also becomes more homogeneous thereby. The wave-lengths of the Reststrahlen were obtained by inserting an interferometer in their path. Discussion of the interference curves shows that the radiation consists of a strong band at 93·0 μ, and a weaker band at 116·1 μ. For the mean wave-length, the value calculated is 98·7 μ. No simple relation is obvious between the wave-lengths of the newly observed bands of metallic reflection and the wave-lengths of the short-wave region of absorption. Nor do the means at disposal permit of deciding whether one of the bands belongs to the ordinary, and the other to the extraordinary ray, as Nyswander has shown to be the case for the pair of bands at 6·6 μ and 11·4 μ. **A. E.**

605. *Optical Behaviour of Thin Metal Films.* **N. Galli and K. Försterling.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 58–70, 1911.)—The optical behaviour of very thin metallic films has been often investigated, especially to ascertain if their constants are the same as for the metal in bulk. The metal is here preceded and followed by different media, both transparent, and the refractive index of the metal is denoted by the complex quantity $n_1 (1 - iK_1)$. Then for the thinnest film of silver the authors find the values below, which are in distinct contrast with the values quoted for the metal in bulk.

	n.	K_1.
Massive Silver	0·17	17·2
Thinnest Film	2·2	0·4

E. H. B.

606. *Grating Diffraction.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 1. pp. 41–57, 1911.)—In 1907 the theory of grating diffraction was derived by Rayleigh directly from the differential equations of electrodynamics, Huyghens' principle being used only for the direction of the diffracted waves. The two cases there treated were those of gratings perfectly reflecting and gratings perfectly transparent. The present

investigation is supplementary to Rayleigh's and extends the treatment to partially reflecting gratings, the results being presented in complicated formulæ which, however, may be replaced by approximations in certain cases. [See Abstract No. 1682 (1907).] E. H. B.

607. *Cylindrical Lenses for Spectrum Apparatus.* **E. Gehrcke.** (Zeitschr. Instrumentenk. 31. pp. 87–89, March, 1911. Communication from the Physikal.-Techn. Reichsanstalt.) — Spectrum lines of feeble intensity are difficult to work with. The author here suggests the use of a cylindrical lens to concentrate the spectrum lines to points, the axis of the lens being perpendicular to the lines; thus the positions of faint lines may be easily found. Johansen has employed a cylindrical lens to increase the sensitiveness of his vacuum thermo-couple [Abstract No. 1759 (1910)]. Another case suggested where cylindrical lenses can be used with advantage is the photography of faint interference bands. Using, say, a Lummer-Gehrcke interference spectroscope, a system of bands is obtained in which the brightness decreases so much that to obtain photographs of the faint bands necessitates considerable over-exposure for the stronger ones. Using a cylindrical lens with the fainter ones, however, photographs of the fainter bands can be obtained without over-exposure of the others. It is obvious that the principle can be applied to all kinds of spectrum apparatus. A. W.

608. *Spectrum Analysis: Krypton.* **C. Moureu** and **A. Lepape.** (Comptes Rendus, 152. pp. 691–693, March 13, 1911.)—Up to the present the only method of estimating the amount of krypton present in a gas mixture was that employed by Ramsay [Abstract No. 15 (1904)]. The authors here describe a spectrophotometric method for estimating small quantities of krypton, which requires only a small quantity of gas, Ramsay's method requiring the treatment of very large quantities. The method is based on the following facts: (i) the extreme spectral sensibility of krypton, especially of the yellow line 5871·12 and the green line 5570·50; (ii) the regular increase of intensity of the yellow krypton line in the spectrum of a mixture of argon and krypton where the concentration of the latter gradually increases from a very small value; (iii) the situation of this line in the region of the spectrum where the eye possesses its max. sensibility, and especially (iv) the well-isolated position of the line, between the argon lines of the same colour (5888·79, 5882·88, 5860·54) and of different intensities. In principle, the method consists of judging the intensity of the line 5871·12 in perfectly determined conditions, and comparing the observed intensity with that furnished, under the same conditions, by mixtures of A and Kr containing known proportions of Kr. The mixtures in which it is proposed to estimate Kr ought to be solutions of Kr in a large excess of A; small quantities of other rare gases give no inconvenience. The spectrophotometric examination is effected by means of a simple direct-vision spectroscope (Jobin's model), and the lines used for comparison are A 5912·31 and 5860·54, Kr 5871·12. If the quantity of Kr, the only variable from one experiment to another, is in all cases negligible in comparison with that of A, each A-line always has the same intensity if the experiments are performed under identical conditions. To standardise the apparatus, a succession of mixtures containing various quantities of impure A from the air is used, and, under reduced pressure, the intensity of the Kr-line is observed in each case. Curves are then plotted for the different pressures used, showing the intensity for different impure A-concentrations. Then, knowing the intensity of the

Kr-line in the gas mixture experimented on, the quantity of Kr present can be found with the help of the curves, using Ramsay's determination of the proportion of Kr to A in the air. The least quantity of Kr that can be estimated in 4 cm.^{3} of the A-Kr mixture is about 0·001 mm.^{3}, *i.e.*, about 4×10^{-6} mgm., or 2·5 parts by volume in 10^7. In all the experiments, the Kr is accompanied by Xe. The only line of this element which may possibly be used for estimation purposes seems to be the indigo blue 4671·62 ; but the variations of this line seem to be less regular and more difficult to judge than those of the Kr yellow line. A. W.

609. *Absorption Spectra of Certain Salts of Cobalt, Erbium, Neodymium, and Uranium, as affected by Temperature and by Chemical Reagents.* **H. C. Jones** and **W. W. Strong.** (Amer. Chem. Journ. 45. pp. 1–36, Jan., and pp. 113–159, Feb., 1911.)—With the exception of uranyl nitrate in water, which gives a spectrum differing widely from that of other uranyl salts, it is found that the spectra are dependent to a far smaller extent on the nature of the acid radical than on the nature of the solvent. This is attributed to the association of the coloured kathion with molecules of the solvent in accordance with the theory put forward by Kohlrausch for aqueous solutions. The bands can sometimes be subdivided by change of solvent or addition of various agents, *e.g.*, the band of neodymium salts in water at λ4274 may become a doublet or a triplet in other solvents ; similar changes are produced in the case of 6 bands near λ5000 produced by uranyl salts in acetone, several of which become doublets or triplets when hydrochloric acid is added. T. M. L.

610. *Discussion on the Intensity Distribution in the Doppler-effect of Canal Rays.* **J. Stark.** (Deutsch. Phys. Gesell., Verh. 13. 5. pp. 198–202, March 15, 1911.)—Gehrcke and Reichenheim have advanced the hypothesis that the two maxima in the canal-ray Doppler-effect can be explained on the assumption that monatomic and diatomic molecules of hydrogen are present. They base their arguments upon results which tend to show that the distance of the two maxima from the "rest" line are in the ratio $\sqrt{2} : 1$. It is now argued that the work of Paschen, Steubing, and the author shows that this ratio for values of the kathode-fall under 1500 volts may be greater than 1·41. The same has been shown with other experimental conditions by Gehrcke and Reichenheim for values of kathode-fall up to 1170 volts. From observations mentioned, it further follows that with large values of kathode-fall the ratio may be smaller than 1·41. It is likewise shown that the explanation of the disappearance of the intensity minima in the Doppler-effect in hydrogen canal-rays on account of the admixture of heavier gases causing scattering of the rays, is probably correct. [See also Abstracts Nos. 1428 (1910) ; 158 and 842 (1911).] A. E. G.

611. *Duration of Phosphorescence of Uranyl Salts.* **J. Becquerel.** (Comptes Rendus, 152. pp. 511–513, Feb. 27, 1911.)—It is known that the lower the temperature the greater is the duration of phosphorescence. Lenard has shown that we may consider three phases for each band of phosphorescence : the warm phase in which the emission of light is proportional to the excitation (fluorescence), the permanent phase in which the emission is prolonged after the excitation, and the cold phase which corresponds to a storage of luminous energy without emission. It has been shown by the author and others [see Abstract No. 1404 (1909)] that certain uranyl salts have remarkable phosphorescent properties. These salts are now examined to ascertain whether the duration of their phosphorescence is independent of the temperature. The simple or double salts of organic acids, such as acetates, tartrates, oxalates, &c., follow clearly the usual rule, having much longer phosphorescence at low than at ordinary temperature. Other salts such as chloride, autunite, are a little more persistent at the temperature of liquid nitrogen than at ordinary temperatures. On the other hand, the sulphates (simple and double) and the nitrate do not show any change in the duration of the emission with change of temperature. The sulphates are perhaps a little more luminous at low temperatures, but the nitrate behaves in a similar manner under all temperature conditions, the light emitted undergoing neither change in intensity nor in duration. A. E. G.

612. *Kathode-ray Fluorescence of Sodium Vapour.* **R. W. Wood** and **R. H. Galt.** (Astrophys. Journ. 33. pp. 72–80, Jan., 1911.)—A new spectrum has been obtained from the negative glow of a vacuum tube containing sodium vapour. This spectrum shows the D lines, the first and second subordinate series, the green fluorescent bands excited by white light, a series of symmetrical bands in the red and yellow, two unresolved bands in the blue and violet, and a large number of new lines, some of which may, however, coincide with the spark lines. The red and yellow bands and the violet bands have been found in no other spectrum of sodium vapour. The vacuum tube, 36 cm. long and 3·3 cm. in diam., was made of steel and was connected by a side tube to a mercury pump. The steel tube itself formed the negative electrode; the positive electrode was a nickel wire carried in a glass cap cemented to one end of the steel tube. The electric discharge passed from the end of the Ni wire, inside the steel tube. The opposite end of the tube was closed by a quartz window. The current was obtained from an induction coil, capable of sparking 10 in. in air. The potential could be adjusted over a very wide range almost continuously. The steel tube was heated by a single Bunsen burner. To obtain the spectrum a piece of sodium was placed in the middle of the tube and the pressure reduced to a few mm. of mercury. The flame was then applied and pumping continued. When the pressure was 2 mm. or more the ordinary secondary spectrum of hydrogen was obtained whether the tube was hot or cold. If the tube was kept hot, and the pressure reduced below 2 mm., the hydrogen glow began to give way to the sodium discharge. A bright yellow ring of light, touching the inner wall of the tube, appeared over the molten sodium, and as the pressure decreased this light became intenser, contracting towards the centre of the tube. The whole discharge took place through the sodium vapour. The best conditions for obtaining the red and yellow bands, which are made up of some 600 lines, are: high vacuum (0·1 mm.); a fresh supply of sodium in tube; high-potential discharge; high temperature. A curious relation exists between the kathode-ray spectrum and the fluorescent spectrum excited by white light when the pressure of the nitrogen in the tube is about 1 cm., the dark bands of the kathode-ray spectrum then coinciding with the bright bands of the fluorescent spectrum. An entirely different fluorescence, excited by white light, in no way related to the kathode-ray spectrum, is obtained from sodium vapour when the nitrogen is at a pressure of only 2 or 3 mm., a matter which requires further investigation. The coincidence of the green kathode-ray bands with the green fluorescent bands may be a secondary effect. It seems probable that the kathode rays excite the lines of the subordinate series, which in turn excite by resonance the green fluorescence. The lines of the subordinate series between λ5200 and 4500 are so numerous that the resonance spectrum due to them would appear almost identical with the white-light fluorescence spectrum. The absence of the resonance spectrum in the yellow and red is due to the fact that there are so few strong exciting lines in that region. This hypothesis is supported by the fact that the green bands are much less intense than the red kathode-ray bands. At a certain stage in the warming of the sodium the band spectrum contained a number of strong orange lines which turned out to be the secondary lines of hydrogen. They usually disappeared at pressures below 1 mm. A. E.

613. *Distribution of Secondary Röntgen Rays and the Electromagnetic Pulse Theory.* **C. G. Barkla** and **T. Ayres.** (Phil. Mag. 21. pp. 271–278, Feb., 1911.)—Experiments on the phenomena of scattering Röntgen rays furnish what appears to be the strongest evidence in support of the electromagnetic pulse theory. It is shown that the intensity of scattered radiation in any direction is proportional to $1 + \cos^2 a$, and may be written $I_a = I_{\pi/2}(1 + \cos^2 a)$, the suffix denoting the angle between the direction of radiation considered, and that of propagation of the primary radiation. Experiments are now carried out in order to test this theory. Carbon is used as the scattering substance, because when it is subject to a beam of moderate penetrating power the secondary radiation at a distance of several cm. in air is principally, if not entirely, scattered radiation. If a true secondary Röntgen radiation—fluorescent Röntgen radiation—is emitted by carbon and other light elements, it is either very easily absorbed and does not penetrate that distance in air, or is so penetrating that it is not excited by a moderately penetrating primary radiation. It seems probable that there are both types of secondary radiation, as with the heavier elements. To avoid complications due to this fluorescent radiation the Röntgen tube was kept fairly soft throughout the experiments. Air saturated at 0° C. with methyl iodide is used as the gas to be ionised. The intensities of secondary radiation proceeding in two directions making equal angles with the normal to the plate are compared. As the distances in both carbon and air through which the measured secondary radiations pass are the same in the two positions, the ionisations observed are proportional to the intensities of the radiation proceeding from the atoms themselves, without subsequent absorption in these two directions. The tabulated values of $I_a/I_{\pi/2}$ show that except in the case of angles 20° and 30°, the agreement between theory and experiment is remarkably good. In these cases the correction for scattering from air is large, and the results are much less reliable. It seems possible that the results for these small angles are vitiated by an irregular refraction effect. Experiments are being made to test this point. Such remarkable agreement between the pulse theory and experiment under limited conditions is shown, that it can only be concluded the apparent variations are capable of special explanation. The experiments on the fluorescent Röntgen radiation (homogeneous secondary radiation) more completely confirm previous experiments showing their uniform distribution and different origin. A. E. G.

614. *Secondary β-radiation from Solids and Liquids.* **S. J. Allen.** (Phys. Rev. 32. pp. 201–210, Feb., 1911.)—The paper is in continuation of the work dealt with in Abstract No. 2064 (1909), and deals with the effect of different angles of incidence on the relative order of the secondary reflected radiations from various substances. Ra was used as source of β-rays, and the scattered radiations were received in a hemispherical chamber where the ionisation produced was balanced through an electrometer by means of an equal amount of the opposite sign furnished by a standard Ra preparation. Solids, aqueous solutions, and pure liquids were tested with angles of incidence 0°, 30°, and 50°. The relative reflected secondary radiations were measured through a thin Al-foil, and also through an additional layer of tin-foil 0·001 mm. thick. In the case of solid reflectors, elements of high atomic weight showed only a small change in their radiating powers with increasing angles of incidence, 7 per cent. in the case of lead from 0° to 50°, while with radiators of decreasing atomic weight the radiation increased largely, in the case of Al 80 per cent., and carbon 110 per cent. between 0° and 50°. The radiation after passing through the tin-foil showed an even more marked increase amounting to 210 per cent. in the case of carbon. The percentage transmission of the secondary rays by the tin-foil at angle 0° was considerably greater for elements of high atomic weight than for those of low atomic weight, while at 50° it was practically the same for all atoms; the results indicating that the velocity of the returned rays is not greatly affected by the nature of the radiating substance except at small angles of incidence. The results with liquids showed the same general characteristics as those with solids and agreed with theory [see Abstract No. 1249 (1910)], those liquids containing a large relative number of heavy atoms having the greatest radiation and the least increase with increasing angles of incidence. The author concludes that the observations agree with the hypothesis that the secondary β-rays consist of the primary ones turned out of their course by collision with the atoms of the radiator. [See Bragg, Abstract No. 1716 (1910).] E. M.

615. *Evolution of Heat by Pitchblende.* **H. H. Poole.** (Phil. Mag. 21. pp. 58–62, Jan., 1911.)—The results of a former determination of the rate of evolution of heat by Joachimsthal pitchblende were considerably greater than was to be expected [Abstract No. 562 (1910)], and the present paper deals with a repetition of the experiments. Three determinations gave (i) $8·15 \times 10^{-5}$, (ii) $6·5 \times 10^{-5}$, (iii) $6·2 \times 10^{-5}$; mean $6·95 \times 10^{-5}$ cals. per hour per gm. The mean obtained in the previous paper was $6·1 \times 10^{-5}$, so that the mean of all the results, $6·5 \times 10^{-5}$ cals. per hour per gm. of mineral, is considerably greater than $4·4 \times 10^{-5}$, the figure obtained on the assumption that each gm. of Ra generates 110 cals. per hour. E. M.

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616. *Grating Images under Special Conditions.* **M. Wolfke.** (Ann. d. Physik, 34. 2. pp. 277–310, Feb. 8, 1911. Extract of Inaug.-Dissertation, Breslau.)—A mathematical discussion of a number of different cases of diffraction-grating images, illustrated by diagrams showing the variation of illumination. E. H. B.

617. *Colour-blindness and the Trichromatic Theory of Colour Vision.* II. **W. de W. Abney.** (Roy. Soc., Proc. Ser. A. 84. pp. 449–464, Dec. 15, 1910.)—Part I. of this paper dealt with complete colour-blindness in its relation to the trichromatic theory of colour vision [Abstract No. 935 (1910)]. The present paper treats of incomplete red or green blindness and its relation to the same theory. A. W.

618. *Refraction at a Cylindrical Surface.* **F. Reiche** (Ann. d. Physik, 34. 1. pp. 177–181, Dec. 30, 1910.)—A method is given for calculating the refraction of a plane wave at a cylindrical surface, Huyghens' principle being used. The result agrees with that found by Debye [see Abstract No. 94 (1910)]. G. E. A.

HEAT.

619. *Thermostat for High Temperatures.* **W. Schuen.** (Elektrochem. Zeitschr. 17. pp. 301–308, Feb., 1911.)—The apparatus described is really a tubular induction furnace, in which the iron tube serves both as magnet core and as secondary circuit. The tube is made of wrought iron; it is surrounded by ten primary coils, the copper wire of which is well lagged with asbestos; a frame of iron wire further surrounds the tube. When the current is switched on, the p.d. and current intensity both decrease at first while the temperature rises; the permeability also decreases and falls off rapidly near the critical temperature; after about 20 minutes the current (about 400 amperes) and p.d. (about 200 volts) become constant, and the temperature keeps at 740° C.; the power factor also rises to the constant value 0·61. The critical temperatures of Ni and of Ni-Fe alloys could be utilised for the construction of thermostats for other temperatures. H. B.

620. *"Radio-balance" for the Absolute Measurement of Radiation.* **H. L. Callendar.** (Phys. Soc., Proc. 23. pp. 1–34; Discussion, p. 34, Dec., 1910. Electrician, 66. pp. 902–905, March 17, 1911. Abstract.)—The various forms of instruments for the measurement of small quantities of radiation are first of all critically and extensively discussed including a new four-grid bolometer. The author then describes the radio-balance in which heat supplied by radiation is directly compensated by Peltier absorption of heat in a thermo-junction. In the simplest form of the instrument, radiation admitted through a measured aperture (2 mm. in diam.) falls on a small copper disc, 3 mm. diam. and 0·5 mm. thick, to which two thermo-junctions are attached forming a Peltier cross. One couple indicates changes of temperature on a galvanometer, while a measured current is passed through the other to compensate for the radiation and reduce the galvanometer deflection to zero. A simple relation between the current required, the Peltier coefficient, &c., gives an absolute measure of the radiation. In practice, two similar discs are mounted side by side in a thick copper box so as to avoid rapid changes of temperature or zero. This form of instrument is suitable for the measurement of solar radiation or strong sources, while its absorption coefficient for radiation must be determined by comparison with a standard. The second form of the instrument is the cup radio-balance which is based on the same principle except that greater sensitiveness is secured by employing a pile of several couples, insulated from the cup, for indicating changes of temperature. The absorption coefficient of the cups is practically equal to unity, while the Joule effect of the current through the Peltier junction is automatically eliminated by passing the same current in series through the opposing Peltier junctions on the two cups, the cup exposed to radiation being cooled, and the cup screened from radiation heated, by the Peltier-effect, while both are equally heated by the Joule-effect. The cup radio-balance was found very suitable for measuring the heat evolved by small quantities of radium, that from 1 mgm. of Ra being capable of measurement to about 1 part in 1000. The values obtained so far show that the heat evolution of Ra in terms of Rutherford's standards is somewhat greater than that given by other observers. E. M.

621. *Temperature of Wires in Open Air.* **B. F. E. Keeling.** (Cairo Scient. Journ. 4. No. 46. 1910. Zeitschr. Instrumentenk., Beib. 5. p. 48, March 1, 1911. Abstract.)—Recently invar wires have been used for base-line measurements in surveying. On account of the small coefficient of expansion of invar it is only necessary to know its temperature to about ±1° C. The question arose during survey work in Egypt as to whether a thermometer suspended in the air gave the temperature of the wire that was used. A copper-constantan thermo-element was used to measure the temperature of the wire, and the results of the investigation showed that so long as the wire is exposed to the sun's rays the wire, for temperatures between 30° and 40° C., is from 0·8 deg. to 3·6 deg. warmer than the air. This difference increases with the altitude of the sun, and also if the wire is blackened. Only when the wire is in the shade or when the sun is obscured is the temperature-difference negligible. Hence it is suggested that thermo-electric methods for the measurement of the temperature of the wire should be employed in preference to the former method. **A. W.**

622. *Flames of Low Temperature supported by Ozone.* **R. J. Strutt.** (Phys. Soc., Proc. 23. pp. 147–151, Feb., 1911.)—In some previous experiments [see Abstract No. 513 (1911)] the yellow afterglow often observed when an electric discharge is passed through a vacuum tube containing air, was found to be due to the mutual action of nitric oxide and ozone, each formed in the discharge. The present experiments are undertaken to examine the action of ozone on other oxidisable gases, to see whether any analogous flame is produced. The apparatus consists of a vacuum discharge tube fed with a stream of oxygen. The ozone thus produced issues through a jet into a wider tube where it meets with a current of some gas or with other substances under investigation; a powerful air-pump is used to maintain the gas currents. The spectrum of the flame produced is observed through a quartz window. With sulphuretted hydrogen mixed with ozone a sky-blue flame is observed which is much inferior in luminosity and volume to that given by nitric oxide. The spectrum ranges from λ2300 to about λ4800. Over most of this range it is continuous, but in the extreme ultra-violet from λ2300 to about λ2600, bands can be distinguished. When a fragment of solid sulphur is placed in the path of the ozone, after a few seconds a blue flame indistinguishable from that obtained with sulphuretted hydrogen is seen to play round the sulphur. From comparison of the spectrum of sulphur burning in air with that observed under the above conditions it appears that sulphur burned in either way gives the same continuous spectrum: superposed on this is a system of bands different in the two cases. Similar results are obtained with CS_2. Sulphur dioxide, however, gives no glow in ozone. Selenium gives no glow in the cold, but when gently heated it is surrounded by a not very conspicuous glow. Arsenic gives no glow and is not visibly acted on. Iodine gives an orange glow redder than that due to nitric oxide; it is oxidised to a yellowish-white solid. The spectrum of the glow in iodine is confined to the red and yellow regions. Hydrogen, ammonia, and CO give no glow. Acetylene, in contrast to most hydrocarbons gives a fairly conspicuous glow of bluish-green colour. The spectrum consists of the Swan bands, together with the hydrocarbon band λ4315, and is thus identical with that of the inner cone of the Bunsen flame. The colour of the flame can be regulated by the acetylene supply. Benzene under some conditions gives a just perceptible glow too faint to be easily studied though attended with a notable rise in temperature. Methane, ethylene, and the vapours of petrol, ether and alcohol give no glow. Napthalene and camphor also fail to give a glow though energetically acted on. Cyanogen gives a white glow, with a purple tinge near the nozzle, when the ozone issues into it. The spectrum shows the cyanogen bands at λ388 and λ387 very strongly, also those at λ359 and λ421. In addition to these there is a band at λ431 which is possibly the hydrocarbon band λ431·5, and another unidentified band at λ415 which may eventually prove of interest in connection with the spectra of comets. Further experiments are in progress. A. E. G.

623. *Studies in Vapour Pressure.* VI. *A Quantitative Study of the Constitution of Calomel Vapour.* **A. Smith** and **A. W. C. Menzies.** (Amer. Chem. Soc., Journ. 32. pp. 1541–1555, Dec., 1910.)—In view of the unsatisfactory nature of the determinations of the vapour pressure of calomel and the fact that they do not justify any strict conclusion regarding the composition of the vapour yielded by calomel, the authors have carried out a series of determinations of vapour pressure by means of the static isoteniscope [Abstract No. 370 (1911)]. The determinations necessary are the vapour pressure of calomel itself, that of a mixture of calomel and mercury, and that of mercury. It was later found that calomel dissolves appreciably in mercury at the temperatures employed, so that a determination of the solubility and lowering of the vapour pressure became necessary. A series of determinations of the vapour pressure of calomel from 360° to 400° was carried out. The boiling-point of calomel was found to be 382·5° C. From the values obtained it was found that calomel vapour even when saturated, is wholly dissociated into Hg and $HgCl_2$, and that molecules of the classes HgCl and Hg_2Cl_2 are not present. As regards the molecular weight of calomel dissolved in mercury, at 360°–400° this was found to be monomolecular.

A. F.

REFERENCES.

624. *Specific Heats at Low Temperatures.* III. **W. Nernst.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 13. pp. 306–315, 1911.) IV. **F. A. Lindemann.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 13. pp. 316–321, 1911.)—Articles occupied with discussions as to the atomic heats and electric resistances of lead, silver, &c., at low temperatures, the endeavour being made to fit the observed values to formulæ. [See Abstracts Nos. 1276, 2200 (1900), also 821, 822 (1910).] E. H. B.

625. *The Caloric Theory of Heat and Carnot's Principle.* **H. L. Callendar.** (Phys. Soc., Proc. 23. pp. 153–189, April, 1911. Presidential Address.)

626. *Thermodynamics of Steam.* **E. Wertheimer.** (Phys. Zeitschr. 12. pp. 91–94, Feb. 1, 1911.)—A mathematical discussion of the properties of unsaturated steam with special references to the work of Ramsay and Young and the theories of Planck. E. H. B.

SOUND.

627. *Resistance Thermometer for Stationary Waves.* **K. Neuscheler.** (Ann. d. Physik, 34. 1. pp. 131–160, Dec. 30, 1910. Extract of Dissertation, Tübingen.)—The stationary waves are produced in a stopped organ-pipe 2·35 m. long with a fundamental of 38 per sec. The adiabatic temperature-changes just inside the stopped end are detected by a thin metal strip which forms one arm of a Wheatstone bridge in use with an Einthoven string galvanometer. A photograph is then taken on a moving ruled paper and shows a simple sine-curve, or a more complicated one, according as the pipe is speaking a simple or a compound tone. The bolometer resistances were of the order 5000 ohms, the temperature-changes measured being sometimes as small as 0·18° C., the amplitude of the vibrations being then 0·058 cm. E. H. B.

628. *Damping of Sound by Frothy Liquids.* **A. Mallock.** (Roy. Soc., Proc. Ser. A. 84. pp. 391–395, Dec. 15, 1910.)—The fact that a tumbler containing a frothy liquid gives a dull sound when struck is familiar to every one, but the author could not find any published explanation of the fact. It would appear that the excessive damping in the case where the obstacles are gaseous, and the intervening spaces filled with liquid, is due to the augmentation of the distortion of the latter caused by the variation of pressure acting mainly on the volume of gas. Following this idea out mathematically the following result is derived:—

$$\frac{\text{Velocity of wave propagation in mixture}}{\text{Velocity of sound in air}} = \frac{(l+1)\sqrt{n}}{\sqrt{(l+n)(ml+1)}},$$

where the *ratios* of the *volumes* of liquid and gas, *densities* of liquid and gas and *elasticities* of liquid and gas are respectively l, m, and n. A curve is then plotted with velocity of wave propagation in mixture as ordinates and l as abscissæ. This shows that a very small quantity of liquid, when distributed as in froth, lowers the velocity of transmission enormously, and that the velocity again rises to that of sound in air when the volume of air is about 1/800 of the whole. When l is less than 2, the mixture begins to take the nature of a froth. The velocity rises very gradually as the quantity of air diminishes, reaching, of course, ultimately (and sensibly when $l = 10^6$) the velocity of propagation in water. The dissipation effect is next calculated for a viscous incompressible liquid. Thus, where the viscosity is expressed by $\nu = \mu/\rho$, and L is written for $(l+1)^{1/3}$, the author finds the following formula:—

$$\frac{\text{Work dissipated per vibration}}{\text{Total energy in liquid}} = \frac{8\nu T}{2r_1^2}\,\frac{L^2+L+1}{L^2},$$

r_1 being the radius of the bubble and T the period of vibration. The efficiency of the bubbles in damping vibrations increases rapidly both as their diam. and the distance between them diminishes. The damping per vibration is proportional to T, but for a constant time is independent of T, the reduction for all periods being in the ratio of $1/e$ when $t = r_1^2 L^2/\nu(L^2 + L + 1)$.

E. H. B.

629. *Detection by Dust Figures of Inaudible "Sounds" from Electric Sparks.* **A. Campbell and D. W. Dye.** (Electrician, 66. pp. 862–868, March 10, 1911.)—The high-frequency electrical oscillations produced by spark discharge are nowadays familiar to most electrical workers, and in wave telegraphy the wave-lengths are measured with ease and accuracy. It is not, however, very generally known that an oscillatory spark discharge gives out at the same time intense, but usually inaudible, sound- (or air-) waves of very high frequency. The intensity of these air waves has been pointed out by R. W. Wood [Abstract No. 1254 (1905)], and more recently W. Altberg [Abstract No. 1045 (1907)] has succeeded in measuring the wave-lengths down to 1 mm. (frequency $n = 340,000$ per sec. nearly). Altberg's measurements were made by means of diffraction gratings formed of rods from 1 mm. up to 6 mm. in diam. and used in an almost similar manner to the three-thousandfold finer gratings by which the wave-lengths of light are determined. In connection with their work on the calibration of wave-meters the authors have recently succeeded in proving the existence of sound- or air-waves of much higher frequency than those mentioned, and have measured their wave-lengths by the extremely simple methods of Kundt's dust figures showing stationary sound-waves in tubes. The method had already been used for measuring very high sound-waves above the limits of audition by Koenig for small tuning-forks, and by Edelmann for a Galton whistle going up to a frequency of 170,000 per sec. (wave-length $\lambda = 2$ mm.) [Abstracts Nos. 88 and 1822 (1900)]. In the authors' experiments various sizes of tubes were used, of lengths from 10 cm. to 70 cm., and of diams. from 8 mm. to 20 mm. The lycopodium was carefully dried, and a very small amount of it was left in a line along the bottom of the tube. The oscillatory spark was made in the usual manner by the help of suitable capacities and inductances, giving a range of electrical frequency from 100,000 up to 1,000,000 per sec. Since each oscillation gives two sparks, and each spark produces, presumably, one sound-wave, the frequency of the sound-waves should be twice that of the electrical ones. The glass tube was held horizontally with its open end close to the spark, which was made tolerably vigorous by lengthening the spark-gap. When the conditions were favourable, the lycopodium quickly arranged itself into a series of very fine streaks. These were distinct up to a sound frequency of at least 900,000 per sec., though in that case they are quite 50 per cm., and sometimes at lower frequencies a series 10 cm. long could be measured. Although individual experiments showed considerable irregularity the sound frequencies were thus determined for a number of cases from $n = 140,000$ up to 800,000 per sec., and at the same time the electrical frequencies were measured by means of a wave-meter. The agreement between the doubled electric frequency and the sound frequency was on the average within about 0·5 per cent., and thus the experiments gave a corroborative calibration of the wave-meter used. The paper is illustrated by two reproductions of photographs of the dust-figures. **F. Mather.** (Ibid. p. 960, March 24, 1911.) E. H. B.

630. *High Sound Vibrations from Electric Sparks.* **J. Wertheim Salomonson.** (Electrician, 66. pp. 959–960, March 24, 1911.)—Referring to a previous article by Campbell and Dye [see preceding Abstract], claiming to have shown, by Kundt's dust figures, that from electric oscillatory sparks of given frequency sound-vibrations of double that frequency occur, the present author states that he was working on this subject in 1902 and 1903, but was unable to attain certainty on this point, some of the discrepancies he

observed amounting to 25 per cent. He considers that a series of careful measurements taken under widely different conditions is necessary before it can be concluded that the Kundt method is reliable for this special purpose.

E. H. B.

631. *Small Motion at Nodes of Vibrating String.* **C. V. Raman.** (Phys. Rev. 32. pp. 309–315, March, 1911.)—It is generally recognised that the nodes of a string which is maintained permanently in oscillation cannot be points of absolute rest, as the energy requisite for the maintenance of the vibrations is transmitted through these points. To demonstrate this fact the author has found the stroboscopic method convenient, the frequency of the illumination being nearly *twice* that of the string. A tuning-fork maintains the string in oscillation in any convenient number of loops, while a second fork of nearly twice the frequency forms the interrupter of an induction coil the spark from which gives the periodic illumination; both forks are electrically self-maintaining. The string is seen in *two* slowly-moving positions, which represent opposite phases of the actual motion. If the nodes were points of absolute rest, then the two positions seen under this illumination would intersect at fixed points. On account, however, of the small transverse motion at the nodes, the points of intersection, or "fictitious nodes," are seen to execute a motion of *large* amplitude parallel to the string—the range of the motion being equal to the whole length of a loop. This motion, best seen under a magnifying glass, is represented in a reproduced photograph, in which are shown nine successive stages at equal intervals of a complete cycle. A theoretical discussion follows and two other methods of experiment are mentioned. [See Abstract No. 120 (1910).] E. H. B.

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632. *Sound Analysis by Vibrating Plates.* **D. A. Goldhammer.** (Ann. d. Physik, 33. 1. pp. 192–208, Aug. 5, 1910.)—A theoretical examination of the power of a plate clamped at the edge to respond to the complex waves falling upon it which is tacitly assumed in the applications of such plates to phonographs, gramophones, &c. E. H. B.

633. *Vibrations of Fork.* **G. Sizes** and **G. Massol.** (Comptes Rendus, 151. pp. 437–439, Aug. 8, 1910.)—The great number of harmonics found in the vibrations of a fork [see Abstract No. 1295 (1910)] the authors now ascribe to its vibrations in the plane parallel to the two branches and in the perpendicular plane. The paper is accompanied by several traces showing the nature of this dual vibration.

E. H. B.

634. *Difference-tones of Higher Orders.* **E. Waetzmann.** (Ann. d. Physik, 33. 6. pp. 1299–1304, Dec. 20, 1910.)—A discussion of the relative intensities and derivation of the higher difference-tones. It is here contended that these higher-order tones should be regarded (equally with those of the first order) as derived from the primary tones. E. H. B.

635. *Analysis of Musical Tone.* **P. H. Edwards.** (Phys. Rev. 32. pp. 23–37, Jan., 1911.)—A set of resonators is used of the adjustable cylindrical type, each being provided at the opening with a Rayleigh disc of mica suspended by a quartz fibre and carrying at the foot a glass dumb-bell in oil to check the motion. The deflection of each such disc is read by the spot of light from a concave mirror on the disc. By this means the tones of a violin, cornet, and other instruments were tested. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY

636. *Cloud Method of determining Elementary Charges.* **K. Przibram.** (Phys. Zeitschr. **12.** pp. 62–63, Jan. 15, 1911. Akad. Wiss. Wien, Sitz. Ber. **119.** 2a. pp. 869–935, June, 1910.)—Gives some further distribution curves in which the charges are entered as abscissæ and the number of charges of each value, classified in groups differing by 10^{-10} electrostatic unit, as ordinates [see Abstracts Nos. 1471, 1745 (1910), and 282 (1911)]. The effect of adding a further 210 elementary charges of phosphorus fog particles is to emphasise the maxima still further. Cunningham's correction moves all the values slightly downwards. The final curve, which includes all the 1210 individual values, has maxima at 5·6, 9·8, and 13·2 × 10^{-10} e.s. unit respectively. There are subsidiary peaks at 15 and 19, and between 23·6 and 25·6. A smaller maximum occurs between 2 and 3 × 10^{-10} in the curve embodying the first 100 values, but disappears as the number of values embodied increases. More recent measurements with burning camphor vapour, 33 in number, give groups differing by 3·7 × 10^{-10}, and others, with the fumes of burning sulphur, differ by 3·4 to 3·5 × 10^{-10} (J. J. Thomson's value for *e*). E. E. F.

637. *Contact Potential.* **de Broglie.** (Comptes Rendus, **152.** pp. 696–698, March 13, 1911.)—The author has previously dealt with the effect of thin layers of moisture on the surfaces of metals in the mechanical methods of ionisation [Abstract No. 955 (1910)]. The present paper treats of the variation of the apparent contact potential between two metallic plates under the influence of layers of moisture. Beil [Abstract No. 852 (1910)] has recently attributed to the same cause a modification of the contact potential of metals due to the presence of a neighbouring plate. In the present research various means were adopted for removing, as far as possible, the moisture layers, and the compensation method was employed in the measurements of the contact potential. Experiments were made with the following metals, compared with a standard plate of brass thickly gilded: Ag, Pt, Fe, steel, Zn, Ni, Cu, Al, Sn, Sb, and Bi. The initial p.d. was of the order of a volt in the majority of cases, and this was reduced to only a few hundredths of a volt in the large drying chamber (about 1 m.^{3} capacity) used in the experiments. It appears probable that this would be still further reduced by a more perfect method of drying. It also appears that, in a dry atmosphere, some easily visible alterations of the surfaces modify the p.d.'s much less than in the ordinary conditions. Certain metals, such as Fe and Zn, are easily dealt with; others, such as Al, resist more, the difference being doubtless due to the layer of oxide covering them. From these results it is seen that almost the whole of the ordinary contact-potential between metals is due to the presence of films of moisture, and that if the surfaces are dry, the order of magnitude of such p.d.'s is not more than a few hundredths of a volt. A. W.

638. *Atmospheric Electricity.* **A. Gockel.** (Phys. Zeitschr. **12.** pp. 65–66, Jan. 15, 1911.)—Describes measurements of the dispersion and emanation-content of sea air, made on a voyage from Triest to Constantinople and back.

The dispersion apparatus consisted of a Wulf electrometer, to which, as the dispersion body, was attached a blackened copper rod 88 cm. long and 5 mm. in diam. The capacity of the whole was 9·17 cm., and the ratio n, of the capacity of the electrometer alone to that of the whole apparatus was 0·46. It was found that the dispersion coefficient a could be calculated with sufficient accuracy from the formula $a = [100/(1 - n)] (1/t) \log (V_1/V_2)$, where V_1 and V_2 are the observed potentials at the beginning and end of the time t. The results of the whole research showed that the dispersion over the sea is not appreciably smaller than over the land. The dispersion coefficient varied between 4·4 and 8·5 per cent. per min. Higher values of from 10·9 to 14·5 per cent. were observed in the Gulf of Smyrna, in the canal between Mytilene and the mainland, and immediately after leaving the Dardanelles. Mazelle found at Triest a_- to be 0·50, and a_+ 0·55 per cent., but the apparatus used was so different to that employed in the present research that the results are not comparable [see Abstract No. 1455 (1905)]. With the air very damp, especially with a fine mist over the sea, the ratio $q (= a_-/a_+)$, usually about 0·82 to 1·0, rose to about 1·5. The smaller values of q were found usually when the sea was very calm—a fact already observed by Pacini [Abstract No. 658 (1908)]. A further research on the absolute content of radio-active induction of the atmosphere was undertaken, following the method used by Kohlrausch and by Kurz. The results obtained will be published later, but it is stated that the value obtained agrees well with the results of Elster and Geitel, Lüdeling, Sieveking, and Rachlew. A. W.

639. *Electrical Dissipation at Kew Observatory.* **C. Chree.** (Phil. Mag. 20. pp. 475–493, Sept., 1910. From the National Physical Laboratory.)—Regular observations have been made during the years 1907 to 1909 with an Elster and Geitel dissipation apparatus between 2 p.m. and 4 p.m. whenever the atmospheric conditions permitted. The values obtained for a_+ and a_-, the percentage losses per minute of positive and negative charges, are considerably lower than those recorded at most continental stations. The largest values actually measured were 1·80 for a_+ and 8·41 for a_-. The values obtained for q, the arithmetic mean of individual day's values of a_-/a_+, or q' the value of $(\Sigma a_-)/(\Sigma a_+)$, are exceptionally large. This can be traced to a persistent tendency for a_- to be substantially larger than a_+. The results show a well-marked seasonal variation in dissipation. Taking the mean of a_+ and a_- we have the max. dissipation in June 0·870 and July 0·867, and the minimum in Jan. 0·416, Feb. 0·428, and March 0·898. The annual variation is the opposite of that of P, the potential gradient, but the difference between summer and winter is less pronounced. The results are next examined with a view to determining their dependence on meteorological conditions, or with the potential gradient. *Potential Gradient.*—There is a distinct association, the year round, of high values of a_+ and a_- with low values of P, but this association is decidedly less marked in summer than in winter or at the equinoxes. *Temperature.*—Large values of both a_+ and a_- are apparently associated with high temperature for the time of year, but the closeness of the association is much more conspicuous in winter than in summer; in fact in summer it tends to disappear. In winter there is also an association of high temperature with low potential gradient. *Pressure.*—High pressure is associated with low values of a_+ and a_-, but the association is much less apparent in winter than in summer. The association of high potential with high pressure is marked. *Cloud.*—High values of a_+ and a_- and low values of P appear to be associated with the prevalence of much

cloud. An attempt is also made to ascertain whether the electrical phenomena associated with the different types of cloud varied. The presence of cumulus has a distinct tendency to be associated with low values of P and of a_+, but with high values of a_-, and so of q. The pressure of cirro-stratus seems to have exactly the opposite effect so far as dissipation is concerned, but the apparent association with high values of a_+ is at least doubtful. Stratus appears to be associated with a slight rise of a_+ and fall in a_-, and a very decided fall in P. *Bright Sunshine.*—On the average day of bright sunshine during the time of the observation a_+ was 14 per cent. and a_- 15 per cent. below its mean value for the season, while P was 6 per cent. in excess of its mean value. There was no appreciable effect on q. *Visibility.*—Days of high visibility are specially conspicuous for large values of the dissipation. *Wind Direction.*—There is a very pronounced association of high value of a_+ and a_- with southerly and westerly winds, and an equally pronounced association of high values of P with northerly and easterly winds; q seems to be independent of wind direction. The great mass of London lies to NNE. and E. of Kew, and but few houses come within a 1¼-mile radius. On the other side there is a narrow fringe of houses extending from NNW. through W. to SE. within a mile radius. R. G. K. L.

DISCHARGE AND OSCILLATIONS.

640. *Volume Ionisation by Light of Extremely Short Wave-length.* **F. Palmer, Jr.** (Phys. Rev. 32. pp. 1–22, Jan., 1911.)—Lenard has shown that a volume ionisation takes place when ultra-violet light passes through air [Abstract No. 1028 (1900)], and in the present paper the author has investigated the effect of the part of the spectrum in the Schumann region below λ1800, this being the lowest wave-length operative in Lenard's experiments. As source a discharge tube filled with purified hydrogen was used, the light from the discharge passing through a screen between two clear white fluorite plates into the ionisation chamber. The space between the fluorite plates was filled with oxygen at an adjustable pressure so that the absorption of the Schumann waves could be varied in a known manner. In this way an estimate of the variation of the ionisation with wave-length was obtained for different gases, and found to increase considerably with decreasing wave-length in the region below λ1850. The ionisation in air, oxygen, and nitrogen was considerable, while that in hydrogen was exceedingly small, the high value for nitrogen being interesting in consideration of the transparency of nitrogen to the Schumann waves. Very large currents were obtained when either alcohol or ether was mixed with the gas under examination. Special experiments showed that the ionisation observed was not due to photoelectric effects on dust particles present as suggested by E. Bloch, nor to photoelectric action at the inner surface of the ionisation chamber as suggested by Stark. Under certain conditions, however, fatigue could be produced, this being found to be due to ozone. E. M.

641. *Ions and Neutral Particles present in Freshly Prepared Gases.* **L. Bloch.** (Le Radium, 7. pp. 354–362, Dec., 1910.)—The paper is a continuation of the author's previous work on the subject [see Abstracts Nos. 602, 1006 (1910)] in which the charges produced by bubbles of freshly prepared hydrogen were found to resemble those produced by mechanical spraying or bubbling. The ionisation appears to be due to the projected small particles produced at the rupture of the surface of the liquid by the bubbles. In the present experiments a piece of zinc was placed in very dilute HCl so that fine bubbles of hydrogen were slowly generated. Over the surface of the liquid was placed an electrode connected to an electrometer, and the ionisation current was measured between the electrode and the liquid for different voltages. It was found that even up to 1100 volts there was no sign of saturation, the current being the same for both positive and negative ions and practically proportional to the voltage. The author explains this by assuming that neutral particles are produced which are separated into ions by the electrostatic field, these ions carrying charges from two to three times the electronic charge and increasing in mobility with increase of the electric field which creates them. These neutral particles were calculated to be too small to be visible in the ultramicroscope and thus to differ from those found by de Broglie over "inactive" liquids [Abstract No. 955 (1910)]. The ionisation effect of these neutral particles was found to be much greater than that of the negative ions produced by bubbling which have been previously investigated, although both are acted on in the same way by layers of foreign liquids placed on the surface of the HCl, being completely suppressed by "inactive" liquids (benzene, &c., *loc. cit.*). E. M.

642. *Mobility of the Positive Ion in Gases at Low Pressures.* **G. W. Todd.** (Cambridge Phil. Soc., Proc. 16. pp. 21–25, Feb. 15, 1911.)—The gases experimented on (air, CO_2, hydrogen, and ethyl bromide) were ionised by Röntgen rays and a modification of Rutherford's alternating-current method was employed. A constant stream of ions was directed from a gauze to a plate 5 cm. above it connected with a tilted electroscope, the latter being deflected only when the ions could reach the plate in time T/2, where T is the period of the alternating e.m.f. applied to the gauze. If E_0 is the max. e.m.f. applied, and d the distance the ions had to travel in time T/2, the mobility u is given by $\pi d^2/E_0T$. In the case of the negative ions it was found that below 20 cm. of Hg the product of the pressure and mobility increases rapidly with decreasing pressure, results being obtained of the same order as those of Kovarik [Abstract 966 (1910)]. With the positive ions, however, the product of the pressure and mobility was found to be constant down to a few mm. of Hg in the cases of all the gases employed. Thus if the positive ion is an aggregation of molecules round a positive charge, that aggregation persists down to the pressures used in these experiments; while if there is a positive unit of electricity it is, under the conditions of the experiments, inseparable from the molecules forming the ion. E. M.

643. *Mobility of Positive Flame Ion.* **S. G. Lusby.** (Cambridge Phil. Soc., Proc. 16. pp. 26–34, Feb. 15, 1911.)—The experiments of Gold and of H. A. Wilson [Abstracts Nos. 1067 (1907), 1919 (1909)] have demonstrated that in high-temperature flames the negative ion is a pure electron. The present paper deals with the mobility of the positive ion, and the results indicate that its mass at 1500° abs. is equal to that of the hydrogen atom. The method used was a modification of that which H. A. Wilson used in 1899, two mesh electrodes being placed horizontally, one above the other, in the flame. The critical potential required to drive back the positive ions against the uprush of the gas was determined, and from a knowledge of the distribution of the potential gradient between the electrodes the mobility was calculated. The critical potential was found to be the same for different salts of metals of the alkali and alkaline-earth groups, and the value of the mobility

at 1450° abs. was found to be 290 cm./sec. in practical units. Theoretical considerations gave $k = 276$ on the assumption that the mass of the ion is equal to that of the hydrogen atom. E. M.

644. *Effect of Temperature on Ionisation of a Gas.* **J. H. Clo.** (Astrophys. Journ. 33. pp. 115–124, March, 1911.)—The ultimate purpose of the experiments here described was to determine whether it is possible to change the kinetic energy of the molecule sufficiently to affect the stability of the atom. The ionisation of gases was chosen as a type of the phenomena which involve the separation of the electron from the atom, and which therefore depend on its stability. The observations consisted in the measurement of the ionisation current in a gas within a closed vessel by means of the rate of leak of a charge to an electrometer. An attempt was made to measure the ionisation at constant pressure, but owing to variations and disturbances due to the change in density this method was abandoned, and all observations were made with the gas at constant density. Air and hydrogen were the two gases studied, radium being the ionising agent, and only the γ-rays entering the ionisation chamber. The temperatures were varied from room temperature to about 615° C., so that the absolute temperature and mean kinetic energy were each about trebled. The individual readings were in general constant to within 0·2 per cent. of the mean, showing that the ionisation of air by γ-rays from Ra is independent of temperature to within 0·2 per cent. up to about 600° C. For hydrogen the same independence is shown for temperatures up to about 480° C. [See Abstracts Nos. 649, 1061 and 1674 (1907).] E. H. B.

645. *The Ionisation of Heavy Gases by Röntgen Rays.* **R. T. Beatty.** (Cambridge Phil. Soc., Proc. 16. pp. 46–47, Feb. 15, 1911.)—The present experiments deal with the amount of ionisation contributed by the secondary β-rays excited by Röntgen rays in various gases. A shallow ionisation chamber was filled with SeH_2, and, using Röntgen rays penetrating enough to evoke the characteristic X-radiation of Se, a curve was obtained connecting ionisation with pressure. This curve was convex towards the pressure axis in such a way as to indicate that a large part of the ionisation was due to the secondary β-rays whose paths are curtailed at low pressures. The chamber was then lined with Se, and the curve connecting ionisation and pressure was now found to be linear, indicating that the secondary rays produced in the gas which are stopped by the walls are balanced exactly by the β-rays coming from the Se film. When radiations from Fe, Ni, Cu, Zn, Se were used as sources the relative ionisation of the SeH_2 (to air) was found to be $80 \pm 0·5$, while when Sr, Mo, Ag, Sn, I were used the relative ionisation increased greatly, attaining a value 286 with the radiation from iodine. A large part of the ionisation was found to be due to the β-rays, which also showed a large increase. Similar results were obtained with $Ni(CO)_4$ and AsH_3. E. M.

646. *Probable Ionising Action in the Magnetic Field.* **A. Righi.** (Comptes Rendus, 152. pp. 250–252, Jan. 30, 1911. Le Radium, 8. pp. 135–139, April, 1911.)—It is well known that when a p.d. which is much smaller than that required to produce a discharge under ordinary conditions is applied to the electrodes of a tube containing air at a pressure of the order 1/1000 mm., a current can be established in the tube when it is submitted to the action of a suitable magnetic field. None of the phenomena of discharge are present in the tube prior to putting on the field, so that the action cannot be explained by modifications produced by the magnetic forces upon the movements of ions and electrons. As the result of some previous experiments an hypothesis, based upon the action of the magnetic field upon the moving electrons in the atom, has been put forward to explain the effects observed [see Abstract No. 128 (1911)]. Those experiments were carried out with air at a pressure of some tenths of a mm. In the present experiments the air pressure was reduced to about 1/1000 mm. and the results obtained can be explained in a similar manner. Unexpected effects were, however, observed, *e.g.*, the action of the same magnetic field is found to vary when the signs of potential of the electrodes are changed, or even when the absolute values of these potentials are altered. Further, the presence of a lamina of metal near the positive electrode produces a diminution in the value of the intensity of the field required to bring about the discharge, and, what is still more remarkable, this effect appears to depend upon the nature of the material used ; thus with lead, and to a less degree with Pt, the fields are weaker than are necessary with glass, Al, Cu, Zn, or carbon. A. E. G.

647. *Transport o, Active Deposit.* **E. M. Wellisch.** (Deutsch. Phys. Gesell., Verh. 18. 4. pp. 159–171, Feb. 28, 1911.)—With historical *résumé* and discussion, develops the view that the particles are uncharged, except while they are associated with a gas ion ; that an ion (or it may be the electric charge) during its movement through the gas is for a certain fraction of its life associated with different atomic residues ; and that during this time the atomic residues undergo a steady translation in the direction in which the ions travel. The fact that the active deposit in an electric field practically wholly settles on the kathode indicates that the particles have an extraordinarily great affinity, from whatever cause, for positive charges. Illustrative experiments with smoke are described. A. D.

648. *Travel of Particles in Electric Field.* **G. Reboul and E. G. de Bollemont.** (Comptes Rendus, 152. pp. 758–760, March 20, 1911.)—If Cu and Pt electrodes, separated by mica, be heated, a deposit of copper oxide is found on the Pt. Its contour follows that of the copper, so that particles are projected across. The amount of deposit reaches a maximum in a time ranging from 80 min. at 400° C. or above to 80 sec. at 900°. Thereafter the deposit continuously disappears. The mutual distance must be below 8 mm. ; within this limit the smaller the distance the greater the deposit. The condition of the surfaces affects the results considerably. A. D.

649. *Ionisation of Gases by Light emitted from Geissler Tubes. Selective Effects in the Ionisation.* **H. G. Cannegieter.** (Konink. Akad. Wetensch. Amsterdam, Proc. 18. pp. 1114–1119, April 20, 1911.)—If we consider that the action of ether vibrations upon the molecules of substances is a resonance effect, then, if molecules on which the light shines are struck by vibrations the period of which corresponds to those which the electrons in molecules can emit themselves under certain circumstances, the electrons will acquire by resonance so strong a motion that they are loosened from the molecule and will behave like free particles. From this point of view we may expect that if a given substance in the luminous state emits electrically active rays, this substance, when struck by these particular rays, will be more photoelectric than when it is under the influence of rays from any other source of light. In the experiments the apparatus used consisted of three parts—(*a*) the discharge tube, (*b*) the absorption space, and (*c*) the ionisation chamber—all three of which are air-tight, and can be filled with gases as desired. By this arrangement it is possible to examine the absorption of different gases for the ionising rays, and to study the connection between absorption and ionisation. No selective effects have been observed. The effects caused by hydrogen, nitrogen, and CO radiation are dependent on the pressure of the gas; the mutual proportion of the effect on the different gases varies with the pressure of the gas. The values given of this proportion show that when the pressure is high the ionisation is always strongest in hydrogen, then in CO, nitrogen, air, and oxygen in the order stated. When the pressure in the gas is lowered the proportion changes. A. E. G.

650. *Discharge of Positive Electricity from Sodium Phosphate heated in Different Gases.* **F. Horton.** (Cambridge Phil. Soc., Proc. 16. pp. 89–101, Feb. 15, 1911.)—Recent spectroscopic investigations have led to the conclusion that when a discharge is sent to a surrounding electrode from aluminium phosphate heated in a vacuum the carriers of positive electricity from that salt are molecules of carbon monoxide gas [see Abstract No. 599 (1910)]. The positive leak from a glowing solid would be expected to be greater in CO than in air or other gases if this were the case. With the aluminium phosphate the leak is thought to be due to the phosphorus contained in the salt, and experiments are being carried out to compare the positive leak from different phosphates under different conditions. The experiments described show that as the pressure is reduced the thermionic current rises to a max. value at between 2 and 3 mm. pressure, after which it decreases very rapidly. Garrett, when investigating the positive leak from heated aluminium phosphate obtained similar results [see Abstract No. 117 (1911)]. Neither H. A. Wilson nor Richardson obtained the maximum in their experiments with Pt, so that it would seem to be an effect of the phosphate used. Heating in CO, and also in hydrogen, has the effect of greatly reducing the positive leak in oxygen. It is shown that the surrounding gas has a considerable effect upon the positive leak from sodium phosphate, and the gradual increase or decrease in this leak which occurs on changing one gas for another seems to indicate that it is not a case of the presence of the gas helping or hindering the escape of ions from the surface of the anode, but that the gas molecules themselves diffuse into the anode and take an active part in carrying the current from its surface. A. E. G.

651. *Spectroscopic Investigation of the Nature of Carriers of Positive Electricity from Heated Aluminium Phosphate.* **F. Horton.** (Roy. Soc., Proc. Ser. A. 84. pp. 433–449, Dec. 15, 1910.)—The magnitude of the total quantity of electricity carried from the heated aluminium phosphate to the surrounding electrode justifies us in assuming that the positive ions are set free in sufficient numbers for their spectrum to be observed. The substances evolved during the passage of the discharge are collected in a spherical vessel, and a ring discharge is used. The discharge in this vessel is found to be brighter and more easily worked than the ordinary electrodeless discharge in a straight vacuum tube. The spectroscopic evidence shows that CO, hydrogen, mercury vapour, and possibly oxygen, are present in the apparatus, all of these, with the exception of the mercury, being liberated by heating the Pt strip covered with aluminium phosphate. The values of e/m for the carriers of positive electricity obtained by Richardson make it certain that these carriers cannot be atoms or molecules of hydrogen or mercury. Garrett [Abstract No. 117 (1911)], however, describes an experiment in which the value $e/m = 9700$ for "the lightest positive ions present" when aluminium phosphate is heated on a Pt strip in a vacuum, was obtained. This corresponds with a

mass about equal to that of the hydrogen atom. It would seem, therefore, that Garrett was measuring the specific charge of these ions, which were not detected in Richardson's experiments, and probably form a small proportion of the total ionisation. Reasons are given in the present paper for thinking it doubtful whether oxygen is really present in the free state of the tube. Richardson's values of e/m make the mass of the carriers considerably greater than that of the oxygen atom, and it is probable that the ions are atoms if they consist of an elementary substance. The conclusion arrived at is that the positive ions are molecules of carbon monoxide. The mass of these molecules is very near to that required to fit in with the value of the specific charge obtained for the positive ions from iron, Pt, and carbon, and it is assumed that the carriers of positive electricity are the same in the case of aluminium phosphate. The question arises, Is this CO evolved from the heated aluminium phosphate, or is it produced from the glass walls of the apparatus? It would be much easier to imagine that the CO-spectrum is due to the heating of the glass than that it is evolved from the aluminium phosphate, for the carbonates used in the manufacture of glass might be expected to evolve CO_2, which in a vacuum tube gives the same spectrum as CO. That CO should be evolved from metals and from aluminium phosphate is difficult to believe. No doubt the molecules of CO would more readily act as carriers of positive electricity from a substance if they came from inside that substance than if they only got in contact with its surface. Now, CO has the property of readily diffusing into carbon and into a number of metals; it is also not easily dissociated by heat or by the electric discharge. When a metal is heated in an atmosphere of CO, molecules of the gas would be continually entering and leaving the surface of the metal. Many of those leaving would be ionised, and carry away a positive charge. The CO radical, though compound, acts as an atom in many chemical combinations. It would appear also to have a greater affinity for positive electricity than any of the ordinary gases, as is evidenced by the readiness with which the spectrum of CO shows up in vacuum tubes, often to the total exclusion of the spectrum of other gases which are known to be present. A. E. G.

652. *Periodic Structure of Magneto-kathodic Rays.* **Gouy.** (Comptes Rendus, 152. pp. 853–856, Feb. 13; Errata, p. 544, Feb. 27, 1911. Le Radium, 8. pp. 129–134, April, 1911.)—When the magnetic field is varied, the uniform brightness of the magneto-kathodic bundle varies periodically (except in the dark space), ten alternations having been counted between 500 and 2000 gauss. In the experiments planned to determine whether the magneto-kathodic rays possess any period property by which to account for the above phenomenon, the following arrangements are made. The kathode is a straight wire 2 mm. diam., and the beam emitted by it falls upon a crystal surface so inclined as to receive rays of varying lengths. The bundle produces upon this screen a long band of bluish light, which resolves itself into a series of equal and equidistant figures. These are displaced along the band as the field varies, and they become compressed, like the fringes themselves when the field is increased. These figures have the form of a very pointed V, with sides a little convex, and are joined the one into the other. It is concluded that a group of neighbouring magneto-kathodic rays possesses a periodic structure according to its length. In the hypothesis which explains the magneto-kathodic rays by the rolling movement of the electrons, the V-figure may be regarded as the caustics of the trajectories of the electrons. The periodicity is quite natural if the helices have nearly equal pitch, since after an interval equal to this pitch the trajectories are again in the same relative positions. [See also Abstract No. 509 (1911).] A. E. G.

653. *Rays of Positive Electricity.* **J. J. Thomson.** (Phil. Mag. **21.** pp. 225–249, Feb., 1911.)—In some previous experiments on positive rays when working with very large discharge tubes, the patterns on a phosphorescent screen produced by the positive rays after they had been deflected by magnetic and electric fields were found to be separate parabolic curves; the value of e/m for the particles striking the curve along one of these parabolas being constant. Parabolas giving values of e/m corresponding to the hydrogen atom, the hydrogen molecule, the He atom, the carbon atom, the oxygen atom, and the Hg atom were observed [see Abstract No. 121 (1911)]. This method of observing the parabolas on a willemite screen gives no permanent record of the curves traced, and accurate measurements of the dimensions and positions of the luminous curves are more difficult than they would be on a photograph. For this reason photographic methods are now employed, and two experimental arrangements for doing this are described. Several copies of the photographs obtained are given. In all these photographs the vertical deflection is due to the magnetic field, the horizontal to the electrostatic. Many of the photographs are taken with the magnetic field in one direction for half the exposure, and in the opposite direction for the other half. The curves obtained are seen to be of two types. (1) Short parabolic arcs (primary curves) of varying length, having their heads in the same vertical line, showing that the minimum electrostatic deflection suffered by the particles which produce these curves is the same whatever the nature of the particles may be, and since this is the case we may conclude that the max. p.d. through which each set of particles has fallen is the same. (2) Curves which pass through O, the point on the plate struck by the rays when they are not deflected by either electric or magnetic forces. The portions of these curves near O are straight lines when the electric and magnetic fields are co-terminous. These latter secondary curves may arise either from the dissociation of the uncharged canal-rays—the change from an uncharged particle to a positive ray—or from the reverse process, the change of a positive ray while in the electric and magnetic fields into an uncharged particle by the coalescence with it of a negatively charged corpuscle: a method of distinguishing between these cases is described. It is likewise shown that for such a coalescence to take place, the velocity of the positive ray must be below a certain value; if the velocity is greater than this, the ray behaves like a primary one. There are only a few ions which occur both as primary and secondary: the positive atom of hydrogen with one charge is the most conspicuous example of this class; others are the atoms of mercury and oxygen, and the molecule of hydrogen. A complete list of ions due to secondary radiation is given, from which it can be seen that, with the exception of the hydrogen molecule, there is not one in which the molecule is intact, while many molecules are found among the ions in the primary rays: for example, the molecules of hydrogen, oxygen, marsh gas, and those of the monatomic gases like He and Hg vapour. Again, the ions in the secondary rays carry in many cases more than one unit of charge; thus for example, we have C++, N++, Hg++, He++, suggesting that the positively charged particles when they collide with a molecule in many cases detach more than one corpuscle from it. In the primary rays several types of ions are found even in elementary gases like hydrogen or oxygen. One way of explaining these types of ions would be to suppose that when the energy of the kathode rays exceeds a certain value, they split the molecule into atoms when they impinge against it, while the slower kathode rays only succeed in knocking a corpuscle out of the molecule without impairing the cohesion between the atoms. There appear to be some experimental results which are antagonistic to this view, and another view based upon the probable behaviour towards kathode rays, of a diatomic molecule made up of two oppositely charged atoms is therefore introduced. In the photographs obtained with much smaller tubes it is found that unless the pressure is reduced very low, when the p.d. between the electrodes is very large, almost the only thing to be seen on the plate, whatever gas may be in the tube, is the secondary radiation, negatively as well as positively charged, corresponding to the hydrogen atom; the negative portion often being almost as bright as the positive. When the tube is filled with air, a very faint curve corresponding to the oxygen atom can with difficulty be detected on the plate. This line is, however, generally the first to appear when the photograph is developed: the hydrogen line, though so much stronger in the end, takes a much longer time to develop. It appears as if the hydrogen atoms had penetrated much more deeply into the film than the oxygen ones, but that close to the surface of the film the oxygen atoms produce the greater effect. The ease with which the atom of hydrogen acquires a negative charge does not harmonise well with the usual view as to the electro-positive character of the hydrogen. With this exception, in these experiments the negative charge is only assumed by those elements which have distinctly electro-negative chemical properties.

A. E. G.

654. *Charge conveyed by Magnetic Rays.* **T. Collodi.** (Accad. Lincei, Atti, 20. pp. 27–30, Jan. 8, 1911.)—Righi found that in a tube within a longitudinal magnetic field, the charge borne by the negative particles was greatly reduced; and he explained this as due to the constraints carrying many of these particles into the gyrating systems which give rise to magnetic rays; but he has subsequently pointed out that the increased ionisation within the Faraday layer may cause the charge as measured by the electrometer not to be equal to the charge carried by the particles. The author, by a method of preventing the gyrating systems from reaching the Faraday layer, eliminates the increase in ionisation due to these, and then he finds that for feeble rarefactions (0·2 mm.) the charge conveyed increases rapidly with the field, while with higher rarefactions (0·04 mm.) the increase is at first less marked, then attains a maximum, and then the charge conveyed falls off as the field becomes more powerful. The constant decrease in the charge conveyed, as observed by Righi, seems to depend upon the increase in ionisation above referred to; this increase in ionisation seems to be itself great at feeble rarefactions and to be smaller in higher vacua; and under conditions of pressure which allow the binary systems that constitute the magnetic rays a sufficiently long trajectory the decrease in the charge borne by the kathodic particles remains well marked even after eliminating the cause of error mentioned.

A. D.

655. *Emission of Kathode Rays.* **J. Malassez.** (Le Radium, 8. pp. 67–72. Feb., 1911.)—J. J. Thomson has found by methods based upon the combined magnetic and electric deviations of the kathode rays, a value for m/e much smaller than that given by Simon, who made use of the p.d. between kathode and anode, and the magnetic deviation. Thomson thinks that this divergence cannot be accounted for by experimental errors, and has put forward the view that the kathode rays are not emitted under the p.d. existing between kathode and anode, but originate a certain distance from the former. The result of this is that the kinetic energy of a particle will be less than Ve, where V is the p.d. and e the charge on the particle. Two series of experiments are here described which tend to show that the kathode rays originate at the kathode itself, and consequently in starting from it they receive the corresponding kinetic energy. A. E. G.

656. *Electric Stress at which Ionisation begins in Air.* **A. Russell.** (Phys. Soc., Proc. 23. pp. 86–97; Discussion, p. 97, Feb., 1911.)—In a previous paper [see Abstract No. 565 (1906)], the author has shown that when equal spherical electrodes of 5 cm. diam. are used the values obtained for $R_{max.}$, the max. value of the electric stress at the instant of the discharge, are approximately equal to 88 kilovolts per cm. for sparking distances varying from 0·8 to 10 cm. The values of $R_{max.}$ for smaller distances are appreciably greater than 88, and for very minute distances they attain a very high value. Results obtained since by other observers prove that when suitable precautions are taken the sparking voltage has a perfectly definite value, and it is now generally admitted that at atmospheric pressures the max. electric stress is one of the main factors governing the discharge when the electrodes are at appreciable distances apart. J. E. Almy [Abstract No. 2008 (1908)] has given a direct experimental proof of the existence of a minimum sparking p.d. of about 350 volts, and it is now shown that those experimenters who have obtained sparking voltages smaller than this when the electrodes were only a micron or so apart, must have mistaken the rush of current due to the actual contact of the electrodes for the rush of current which ensues when there is a spark. J. B. Whitehead has recently published values of the electric stress at which ionisation begins in air [Abstract No. 647B (1910)]. He used as electrodes a cylindrical tube and a wire coaxial with it; an alternating p.d. was employed and the inner wire used had diams. varying from 0·089 to 0·475 cm. It is now found that, if a be the radius of the inner wire, the expression $32 + 13{\cdot}4/\sqrt{a}$ gives values for the max. electric stress, in kilovolts per cm., which differ from the experimental results by less than 1 per cent. There is a striking similarity between this formula and that found by the author for the heat emitted per unit area at the surface of a hot wire cooling in air. The early results obtained by Steinmetz when using parallel cylindrical electrodes can be fairly accurately represented by the same empirical formula. Where discrepancies occur, possible reasons are assigned. Another empirical formula is given which is based on the results of Kowalski and Rappel for the sparking voltages between equal spherical electrodes. A comparison of the max. electric stress with the electrostatic attraction at the instant of the discharge is also made. Further work on sparking voltages obtained with unequal spherical electrodes is in progress. A. E. G.

657. *Glow Discharge and Emission of the Alkali Metals.* **G. Gehlhoff.** (Deutsch. Phys. Gesell., Verh. 13. 5. pp. 183–192, March 15, 1911.)—Previous experiments on the glow discharge in metallic vapours are discussed. As the result of the experiments described it is concluded as now established that the lines of the primary series are produced through slow, those of the secondary series through quicker, and those of the dark spectra through still quicker electrons. Through using a supplementary inert gas such as He at suitable pressures, the electrons in the positive column and in the negative glow may be slowed down and the lines of the primary series become very bright; the same result can be obtained by increasing the vapour pressure of the Cs. By suddenly putting on a higher potential through a spark, that is, with higher potential gradient, it is possible, with high He-pressure, to cause such electron velocities that the secondary series are produced, while with as low He-pressure as Cs-pressure the spark lines are also produced. In the kathode rays, with their high velocity, it is principally the spark spectra which are obtained. It is also apparent from the intensity alteration of the lines of the primary series that the collisions of the Cs with the He molecules play a certain part. With equal Cs partial pressures and high He pressures (185 mm.) the line of shorter wave-length of the doublets (455·5 $\mu\mu$) is brighter, while with smaller He pressures the line of longer wave-length (459·3 $\mu\mu$) is clearer. In the Bunsen flame coloured with Cs it is the line of shorter wave-length which is the brighter. Further work on the subject is in progress. A. E. G.

658. *Kathodic Potential-fall in Argon, &c.* **K. Rottgardt.** (Ann. d. Physik, 33. 6. pp. 1161–1194, Dec. 20, 1910. Extract from Dissertation, Berlin.)—In the glow discharge the use of a sound with a long metallic point, as usually employed, does not give true values for the potential at any point; it gives, where there is a potential-fall, an integrated average reading, too high, and the metal points used should not project more than $\frac{1}{10}$ mm. from a narrow glass sheath. There is a marked fall of potential between the limits of the kathodic dark space and of the Faraday dark space; 26 to 50 volts in argon, 26 to 50 in air, 26 to 49 in nitrogen, 38 to 60 in hydrogen. The normal kathodic fall is the lowest value of the p.d. between the kathode (put to earth) and the boundary between the glow and the kathodic dark space, and it is nearly independent of the pressure, the strength of current, or the size of the tube. In argon this normal kathodic fall is equal with metals of the same chemical valency (*e.g.*, Mg, Cd, Zn kathodes), and decreases with increasing valencies; but Pb and Sn act as divalent, and Bi and Sb as monovalent metals. In nitrogen the results are in part similar; in hydrogen they are complicated by a gradual absorption of hydrogen by the metal, which causes a rise in the value of the potential-fall. The addition of 2 per cent. of damp oxygen, of 10 per cent. of nitrogen, or of 35 per cent. of hydrogen to argon, all have an equal effect in increasing the amount of the potential-fall. Abnormal potential-falls (kathode not wholly covered by discharge) present the same relations to the periodic system as normal falls. A. D.

659. *Distribution of Electric Force in the Crookes Dark Space.* **F. W. Aston.** (Roy. Soc., Proc. Ser. A. 84. pp. 526–535, Jan. 26, 1911.)—The electric force in the Crookes dark space and in the negative glow, has been the subject of a considerable number of investigations. The first determination was made by Schuster; his results indicate the presence of a positive charge of electricity whose density decreases in geometrical progression as the distance from the kathode increases in arithmetical progression. Graham found a curious drop in potential near the kathode, but Wehnelt [Abstract No. 1432 (1903)] repeating these experiments, was unable to find this drop of potential, and ascribes it to the fact that the exploring points were not in the direct line of the current. Skinner (Abstract No. 487 (1902)] came to the conclusion that all the fall of potential occurs at the surface of the kathode. Recently Westphal [Abstract No. 718 (1910)] has made a careful series of observations with kathodes of different metals in several gases, using a single

exploring point, in which he finds a definite fall of potential, *e.g.*, about 80 volts for Al in hydrogen, at the surface of the kathode, the electric force a few mm. away appearing, from his curves, nearly uniform. All these measurements were made by introducing exploring sounds. The method now adopted is to shoot a beam of kathode rays transversely through the discharge, the deflection of these rays being taken as a measure of the electric force at that point. The results obtained indicate that the electric force in the negative glow is negligibly small compared with that in the dark space. The electric force in the dark space is very nearly in linear relation to the distance from the negative glow; and hence the dark space is a region of uniform positive electrification ceasing with great suddenness in the negative glow. The total fall of potential inside the dark space calculated from the results obtained, agrees within the error of experiment with that observed across the electrodes. The method of exploring points is inapplicable to the dark space, and the large falls of potential at the surface of the kathode, observed by its use, are probably non-existent in an unobstructed discharge.

A. E. G.

660. *Effect on the Kathode-fall in Gases produced by the Evolution of Gas from the Kathode.* **L. A. Jones.** (Phys. Rev. 32. pp. 328–340, March, 1911.)—The experiments described are divided into two parts, the first dealing with the effect upon the kathode-fall under a constant current density; the second with the effect upon the "normal" kathode-fall. Kathodes of Pt, Zn, Al, and Mg are tested, both in hydrogen and He. The pressures used were such that the negative glow entirely covered the kathode; the Crookes dark space varying in thickness from 1 mm. to 5 mm. The plan in the first set is to use a discharge tube so constructed that after a kathode has been used for some definite time a fresh one of the same metal can be substituted for it immediately without changing any other conditions. This scheme eliminates any effect arising from a change in the gas, and gives, by comparing the final value of the old kathode with the initial value of the new one, a reliable indication of the effect of use on the metal alone. The results so obtained show that the use of metal as kathode with a constant current-density greater than the "normal" does not change the metal in a way such as to appreciably change its kathode-fall, but it does in general lower the kathode-fall by producing some change in the gas. On the other hand, use of a metal as kathode with "normal" current-density increases its kathode-fall, which occurrence appears reasonably explicable only by assuming that in the experiments with greater current-density than normal, the kathode-fall and current-density are large enough to keep the surface of the metal clean by disintegration, while this is not the case with normal current-density.

A. E. G.

661. *Damping Due to Spark in Condenser Circuits.* **W. F. Zorn.** (Jahrbuch d. Drahtlosen Telegraphie, 4. pp. 260–280, Feb., and pp. 382–399, April, 1911.)—Bjerknes' method is employed to determine the damping in condenser circuits due to the form of the spark-gap, the material of the electrodes, and the dielectric between the electrodes. It is found that the damping is less the greater the discharge current and discharge potential. When Eickhoff's arrangement for increasing the regularity of discharge [see Abstract No. 449 (1908)] is used the discharge-potential falls and the damping is increased. Ag, Cu, Al, Fe give practically the same damping, but Zn and Cd very much less than these, Cd giving slightly less than Zn. Different gases between the electrodes give considerable variations in the damping when the gases are at the same pressure, but these variations disappear if the pressure of the gases is so adjusted that the sparking potential is the same for all. In oxygen the damping is much less than in air, but it is still smaller in Cl and much smaller yet in SO_2. In SO_2 with steel electrodes the damping δ is connected with the discharge potential V by the equation $\delta = A + Be^{-aV}$, where A, B, a are constants. Oscillations may be produced by means of a spark-gap *in vacuo*, provided the gas-pressure is so far reduced that the kathode dark space reaches the anode and the formation of the positive column is prevented. T. P. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

662. *Conductivity of Selenium.* **J. Luterbacher.** (Ann. d. Physik, 33. 6. pp. 1392–1412, Dec. 20, 1910.)—The conductivity of selenium is rendered greater under higher e.m.f.'s. [One particular Se cell showed an anomalous decrease of conductivity.] This effect is more marked under direct than under alternating currents. There is, however, no direct proportionality between the applied voltage and the conductivity; the effect is more marked at low voltages than at high. After the application of a higher e.m.f. the original conductivity is gradually regained, but the time taken in doing this presents anomalies from cell to cell. Treatment with high voltages does not affect the sensitiveness to light. The effect of increase of conductivity by high e.m.f.'s is clearly not due to heat liberated by the measuring current. A. D.

663. *Electrical Conductivity of Liquid Metallic Alloys.* **P. Müller.** (Metallurgie, 7. pp. 730–740, Dec. 8, and pp. 755–771, Dec. 22, 1910.)—The author has investigated the conductivities of the liquid alloys of K-Na, Pb-Sn, K-Hg, and Na-Hg completely, dilute solutions of Cd, Sb, and Bi in molten lead, as representing homogeneous solutions and the system Pb-Zn as representing heterogeneous solutions. The conductivity was calculated from the drop of potential in a given length of molten alloy contained in glass tubes for temperatures below 600° C. and in quartz tubes above 600°. Heating was effected by means of an oil-bath below 300°, in an Heræus furnace from 300–1000°, and in a carbon tube furnace above 1000°, the determinations being carried out in an atmosphere of hydrogen. The results were plotted in the form of specific conductivity-concentration diagrams, an examination of which shows that in the homogeneous solutions the addition of small quantities of a metal to one whose temperature-coefficient is normal (0·004) always causes a decrease of conductivity, whereas if the temperature-coefficient be low, addition of a metal which does not form a compound increases the conductivity. If a compound is formed the conductivity is lowered. The addition of lead to tin provides an exception to this rule, lead lowering the conductivity of tin although the temperature-coefficient of the latter is only 0·00059. In the Pb-Sn and Na-K diagrams the conductivity-concentration curve is continuous, but in the amalgams discontinuities occur which indicate the presence of the compounds $NaHg_2$ and KHg_2 in the liquid alloys. The study of the heterogeneous alloys reveals a method of determining the temperature at which separation into conjugate layers takes place, this being accompanied by a sharp break in the resistance-temperature curve. Below this point the resistance is irregular, depending upon the rate of cooling which determines the extent to which separation

takes place. The temperature-concentration curve showing the separation of the Pb-Zn alloys into conjugate layers is somewhat higher than that determined by Spring and Romanoff who analysed the mechanically separated layers to obtain their results. The author has confirmed his results by taking cooling curves of large masses (2–2¼ kg.) of alloys containing 4·29 per cent. and 8·18 per cent. Zn which indicate that solidification of the conjugate layers begins at 415°C., this temperature as extrapolated from the diagram being 419°C. This agreement is taken as confirming the utility of the method in determining the temperature at which alloys separate into heterogeneous liquids. F. C. A. H. L.

664. *The most Suitable Size of Galvanometer Mirrors.* **W. Volkmann.** (Phys. Zeitschr. 12. pp. 76–77, Jan. 15, 1911.)—The author considers that insufficient attention is paid to the influence of the size of the mirror on the sensitiveness of a galvanometer. The moment of inertia of the mirror is proportional to the fifth power of its diam., and the greater it is the less the sensitiveness; on the other hand, the optical power increases with its size. Another point to be taken into consideration is the thickness of the glass. Owing to the production of interference fringes, it is necessary to make use of thicker glass for big mirrors. If $D =$ diam. of the mirror and K is the moment of inertia of the remainder of the moving system the sensitiveness is proportional to $D/K + cD^5$), where c is a constant. For max. sensitiveness the mirror should therefore have one-fifth part of the total moment of inertia. W. C. S. P.

665. *The Causes of Zero Displacement and Deflection Hysteresis in Moving-coil Galvanometers.* **A. Zeleny.** (Phys. Rev. 32. pp. 297–306, March, 1911.)—It is here shown that the displacement in the zero reading which takes place after a first deflection is practically entirely due to the presence of magnetic impurities within the coil. The galvanometer coil was suspended within a wooden frame between the poles of a large electromagnet. In the first experiments a measured current was reversed through the moving coil at intervals of 1 minute and the reading of the zero was taken after each reversal. This process was repeated for various values of the field, the current in the moving coil in each case being adjusted so that the deflection it would give would be 20 cm. The mean change in the zero for each value of the field is then plotted against the field. The curve so obtained is characteristic of induced magnetism. If the zero displacement were due to true set in the suspension fibre the change of zero should be independent of the value of the magnetic field. In the cases observed the largest true set was only 6 per cent. of the whole zero-displacement. The plane of the coil was next set perpendicular to the faces of the poles, and the change in the reading was observed on simply varying the magnetic field. The zero change was approximately proportional to the magnetic field. The behaviour suggests that the magnetic impurities were not uniformly distributed through the body of the coil; it was also shown experimentally that at least a considerable part of the change was due to an alteration in the direction of the magnetic field. In a previous paper by the author it has been shown that the deflection of a galvanometer for a given current depends upon whether that value of the current was reached from a larger or smaller one. The time of vibration of the coil was therefore obtained in various magnetic fields, the intensity increasing to a maximum and then decreasing. The hysteresis curve so obtained has a bend at an intensity of about 1600.

The coercive power is found to be sufficient to account for the observed deflection hysteresis. In addition it was found that the moment due to the magnetism in the galvanometer coils differed considerably even in instruments of the same type and from the same manufacturer. More than two-thirds of the damping on open circuit was found, for ordinary galvanometers, to be due to the resistance of the air and internal friction of the fibre, and less than one-third to the induced currents. The change of sensibility with the intensity of the field was determined with a coil of known magnetic properties and a suspension of known torsional moment. The sensibility was found to increase at a smaller rate than the intensity of the field. W. C. S. P.

666. *The Mutual Inductance of two Parallel Coaxial Circles.* **H. Nagaoka.** (Mathematical and Physical Soc., Tokyo, Proc. 6. 2. pp. 10–14, Feb., 1911.)—In connection with Grover's paper [see Abstract No. 274 (1911)] the author discusses formulæ for the mutual inductance, M, of two circles. He shows that Grover's result is not essentially the consequence of the hypergeometrical series used, but can be arrived at simply from known formulæ. It may be deduced, for instance, from Maxwell's formula. The author has previously given a very rapidly converging q series for M. He now shows it may be reduced to a single hypergeometrical series. Finally he deduces a very simple approximate formula for M in terms of q. A. R.

667. *Precision Measurements on Standards of Self-induction.* **E. Giebe.** (Zeitschr. Instrumentenk. 30. pp. 6–20, Jan., and pp. 33–52, Feb., 1911. Communication from the Physikal.-Techn. Reichsanstalt.)—A discussion, from both the theoretical and the practical points of view, of the kind of errors likely to occur in measurements of self-inductance by bridge methods. The principal effect dealt with is that of distributed capacity of the coils, and this is investigated by the author's own bridge method and by the resonance method as previously used by Lindemann and by A. Campbell [see Abstract No. 982 (1910)]. In the bridge method all of the arms, including that containing the detecting instrument, are carefully screened by shields [see G. A. Campbell, Abstract No. 1506B (1904)] so as to reduce the effect of capacities to earth, and the results obtained for the effective capacity and the induction are in very good agreement with M. Wien's formula. Frequencies from 300 to 5000 per sec. were used. F. E. S.

668. *High-frequency Resistance of Wires.* **J. A. Fleming.** (Phys. Soc., Proc. 23. pp. 103–114; Discussion, pp. 115–116, Feb., 1911. Electrician, 66. pp. 777–778, Feb. 24, 1911. Abstract.)—A table of results is given for higher frequencies than those given previously [see Abstracts Nos. 259B and 721A (1910)], and it is again shown that the results for straight wires agree very well with Kelvin's and with Russell's formulæ. The resistance of one or two spirals is also given, and it is shown that for these spirals the resistance is from 1·5 to 1·8 times greater when the wire is in spiral form than when straight. The values of the resistance of wires of magnetic metals are used to determine the permeability of these metals at high frequencies. T. P. B.

669. *Demonstration of Peltier and Thomson Effects.* **S. G. Starling.** (Nature, 85. p. 512, Feb. 16, 1911.)—A current is passed through an Sb-Bi-Sb bar. Two coils of No. 36 covered copper wire are wound on the bismuth (one near each junction), and by means of leads are placed in the gaps of a metre bridge and a balance produced. On passing a current of 1 amp. through the bars, one junction is heated and the other cooled, which is indicated by a

galvanometer deflection of about 40 mm. due to the change in the resistance of the copper coils. Similarly, to show the Thomson-effect, a bent iron rod is heated to redness at the bent end, while the other (free) ends dip into vessels of mercury. On passing a current of 10 amps. through the rod one portion is heated and the other cooled, showing that the Thomson coefficient is negative. J. J. S.

670. *Thermo-electric Diagram.* **J. D. H. Dickson.** (Roy. Soc. Edinburgh, Trans. 47. 25. pp. 787–791, 1911.)—A careful investigation has been made of the results obtained by Dewar and Fleming in 1895 in an extensive series of observations connecting temperature and thermo-e.m.f. of about twenty metals compared with lead. The author finds that in general the relation between thermo-e.m.f. and temperature is represented by a parabola with a slant axis; the axis of the parabola is not parallel to the axis of e.m.f. Details of the calculations are given in various particular cases, and also a general thermo-electric diagram showing the curves which indicate the relations of the various metals. J. J. S.

671. *E.M.F. of Standard Cells.* **R. T. Glazebrook.** (Nature, 85. p. 508, Feb. 16, 1911.)—A communication from the National Physical Laboratory stating that international measurements of a high degree of accuracy have been completed which show that the Weston normal cell, made according to approved specifications, has an e.m.f. of 1·0183 international volts at 20° C. Accordingly, all standard cells tested at the National Physical Laboratory will be compared with Weston normal cells, of which the e.m.f.'s have been determined by direct measurement to be 1·0183 int. volts at 20° C. [Similar statements have been issued by the Reichsanstalt and by the Bureau of Standards.] F. E. S.

672. *Construction of Standard Cells and a Constant-temperature Bath.* **G. A. Hulett.** (Phys. Rev. 32. pp. 257–280, March, 1911. Electrician, 67. pp. 129–132, May 5, 1911.)—Describes the manufacture of Clark and Weston cells. For the depolariser the author prefers to use electrolytic mercurous sulphate, and its preparation by direct and by alternating currents is described. The alternating-current preparation seems to be the better of the two, although exhaustive tests have not been made. In setting up the cells a very long form of H-vessel is used. The cells are not hermetically sealed, but are closed by corks which are 15 cm. above the liquid of the cell and are never met by it or by the kerosene of the bath. The Clark cells are preferred for constancy, a 7 per cent. zinc amalgam being used. The thermostat is a toluene regulator of large volume, the mercury meniscus moving in a tube 5 mm. in diam. The movement of the mercury surface responds rapidly and exactly to the slightest change of temperature. F. E. S.

ALTERNATING CURRENTS AND MAGNETISM.

673. *Magnetic Constants of Feebly Magnetic Alloys.* **T. Gnesotto and M. Binghinotto.** (N. Cimento, 20. pp. 384–439, Nov.–Dec., 1910.)—An extension of Laws' researches [Abstract No. 2694 (1904)] to further alloys of Sn and Bi, and to alloys of Bi with Cd and Pb, of Cd with Pb and Sn, and of Sn with Pb. Meslin's modification [Abstract No. 2270 (1905)] of Curie and Chenéveau's apparatus has been employed for the magnetic measurements. Sn-Bi alloys are found to be paramagnetic up to about 10 per cent. Bi, when

a transition takes place, and with further increase of Bi they become diamagnetic; alloys of Bi with Cd and with Pb are all diamagnetic. The coefficient of magnetisation of alloys containing no Bi is a linear function of their concentration; alloys of Sn with Cd and with Pb pass from paramagnetic to diamagnetic as the quantity of Sn diminishes, the points of transition corresponding to 88 and 87 per cent. Sn respectively. W. H. Si.

674. *Effect of Traction and Torsion on the Magnetic Properties of Iron in a Magnetic Field.* **G. Ercolini.** (N. Cimento, 20. pp. 317–340, Nov.–Dec., 1910.)—The author has continued his earlier work [Abstract No. 276 (1911)] on this subject, investigating fully the effect of traction and torsion on the magnetic properties of iron when placed in either a constant magnetic field or a variable field produced by superimposing on a steady field a coaxial alternating one. In a constant field, on the curve of first magnetisation, the first traction produces the phenomena of Matteucci and Villari, but with subsequent traction the Matteucci-effect is always observed if the magnetic field is less than 5 c.g.s. units, and in other cases the Villari-effect. After the magnetic cycle has been completed the influence of traction varies according to the point of cycle at which it commences; in weak fields up to 5 units the value of the magnetic moment is brought nearer to that it possesses along the curve of reversible magnetisation, and in fields of 5–35 units the first traction produces a max. magnetisation. The Matteucci-effect is only observed with the first traction in fields of about 5 units; in very weak fields (1 unit or less) it is not produced. In a variable field the effect of traction is very similar to that observed in a constant field after the magnetic cycle has been completed. The degree of variation produced by traction in the double field is very different from that in a constant field, there being little, if any, increase of magnetisation, and the most notable result of traction in this case is to diminish or destroy the Matteucci-effect. If the alternating field reduces the magnetic hysteresis far enough, successive traction always produces the Villari-effect. In sufficiently intense alternating fields torsion invariably reduces magnetisation, whatever the point in the magnetic cycle at which it commences. W. H. Si.

675. *Magnetostriction.* **R. A. Houstoun.** (Phil. Mag. 21. pp. 78–88, Jan., 1911.)—The object of this paper is to derive a relation connecting magnetostriction with the change of magnetisation produced by stress and to test it by the results of experiment. In substance the relation is not new, but in method of statement it is, and the derivation presented here is shorter and simpler than other methods. The paper also proves in a new and simple way a theorem due to Kelvin. A ferromagnetic wire, with pan for weights to stretch it, is considered hanging vertically inside a vertical solenoid with heating jacket. Then, hysteresis being neglected, the state of the wire is regarded as a function of the three independent variables T, F, and H, *i.e.*, temperature, stretching force, and magnetic field. By thermodynamic considerations six independent relations are readily obtained, which are then reduced to the following more convenient set of three:—

$$\partial x/\partial \mathrm{T} = b/\mathrm{T}, \quad v/4\pi \,.\, \partial \mathrm{B}/\partial \mathrm{T} = a/\mathrm{T}, \quad v/4\pi \,.\, \partial \mathrm{B}/\partial \mathrm{F} = \partial x/\partial \mathrm{H}.$$

The first of these three is well known, the second is a theorem which has been derived in another way by Kelvin, the third is the relation with which the present paper is mainly concerned. It states that, if the induction (B) increases when the wire is stretched, the length of the wire increases when it is magnetised, and *vice versâ*. The author then proceeds to derive this relation in another way, viz., solely from the principle of energy without using the second law of thermodynamics. This third relation is then compared with the measurements by Nagaoka and Honda, and found to give as good an agreement as the theory due to Kirchhoff. E. H. B.

676. *Magnetic Properties of Liquid Crystals.* **E. Bose.** (Phys. Zeitschr. 12. pp. 60–62, Jan. 15, 1911. Communication from the Phys. Inst. of the National Univ., La Plata, Argentine.)—The clearing of anisaldazene by magnetic forces parallel to the line of vision may be observed in vertical or horizontal layers 0·5 to 4 mm. thick with fields as low as 600 gauss. The effect takes a perceptible time with weak fields, since the orientation of the liquid crystals is opposed by their thermal agitation. Observations with transverse magnetic fields are of particular interest for investigations of the paramagnetic or diamagnetic properties of anisotropic liquids, and are calculated to decide some outstanding questions with regard to the swarm theory. Such observations have been made with fields up to 4000 units, using anisalpropionic acid and similar compounds, but no clearing was observed. The experiments are to be repeated with more powerful means. E. E. F.

677. *Size of the Magneton deduced from the Coefficients of Magnetisation of Solutions of Iron Salts.* **P. Weiss.** (Comptes Rendus, 152. pp. 367–369, Feb. 13, 1911.)—Dividing the molecular saturations obtained by Pascal for eleven salts of iron by 1123·5, the aliquot part common to the molecular saturations of iron and nickel at very low temperatures, approximately whole numbers are obtained. Most of these form an arithmetical progression, and, calculating back from this series, 1122·1 is deduced as the value for the aliquot part common to the molecular saturations for all iron salts. W. H. St.

678. *Effects of Lightning-stroke.* **R. L. Faris.** (Terrestrial Magnetism, 15. pp. 211–214, Dec., 1910.)—The Cheltenham Magnetic Observatory of the U.S. Coast and Geodetic Survey was struck by lightning on July 12, 1910. The author gives an account of the damage done to the building and the effects produced on the self-recording magnetic instruments. The vertical intensity instrument was thrown out of order, but the declination and horizontal intensity instruments remained in action. The magnets of these latter suffered a sudden but slight displacement, and commenced vibrating symmetrically about their new position. The displacement of the H apparatus corresponded to a decrease of 0·000045 c.g.s. unit, and that of the D instrument to an increase of 1·2′ of west declination. A. D. R.

RADIOLOGY AND ELECTROPHYSIOLOGY.

679. *Cooling of Antikathodes by Circulation of Air.* **G. Barret.** (Archives d'Él. Médicale, 19. pp. 300–307, April 10, 1911.)—One of the greatest difficulties in the construction of powerful Röntgen tubes is the protection of the antikathode from the destructive action of the heat which is produced at the point struck by the kathodic bundle. In order to accomplish this it is necessary to absorb the heat very rapidly—to absorb it upon the spot, at the place itself at which it appears and as it is produced, without the aid of the phenomena of conductivity to dissipate it immediately—and to reduce to a minimum the metallic masses constituting the kathode. These conditions may be realised if we employ as cooling agent a fluid circulating in contact with the

substance to be cooled, and renewed with a sufficient velocity. The manner of applying this principle is simple: the antikathode is consituted by a layer sufficiently strong to resist the kathodic bombardment but sufficiently thin that the transmission of heat through it may be practically instantaneous. This antikathode is arranged as in tubes in which water is employed as the cooling agent, and the cooling fluid (air) is led up to the posterior surface of the antikathode by a small tube so arranged that the air strikes the point corresponding to the point of impact of the kathode rays. The air escapes by an annular space after having swept over the antikathodic surface. This arrangement is found to act so well that a bulb working under an intensity of 10 to 20 milliamps. can be run continuously for some time. The powerful tubes which up to the present could be only employed for very short periods in rapid radiography can now be employed continuously for all ordinary radiographic work. A. E. G.

680. *Comparison of Rays from a Crookes Tube with Radium Rays from a Therapeutic Point of View.* **Dominici, Barcat, and H. Beaudoin.** (Archives d'Él. Médicale, 19. pp. 118–120, Feb. 10, 1911.)—On account of the relatively smaller penetrating power of the rays generated in a Crookes tube only the Röntgen rays are of use therapeutically, while the α-, β-, and γ-rays of radium can all be made use of. Experiments with photographic plates are described which show that, while the Röntgen rays form a clear impression on the plate through $\frac{1}{10}$ mm. of lead, although less clear than that formed by Ra, through $\frac{2}{10}$ mm. its action is much less clear, and it is hardly visible through a screen $\frac{4}{10}$ mm. thick. On the other hand, this increase in the thickness of the screen seems to have had very little effect upon the density of the photographic impression obtained with Ra. It is proposed to divide the Ra rays into two parts: (*a*) Those stopped by screens of 5- or 6-tenths of a mm. of lead, and (*b*) those capable of traversing those screens. The first class includes most of the α- and β-rays, and can scarcely be compared with Röntgen rays, while the second includes hard β-rays and γ-rays. A. E. G.

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681. *Best Windings for Needle Galvanometers.* **W. Volkmann.** (Deutsch. Phys. Gesell., Verh. 13. 4. pp. 172–178, Feb. 28, 1911. Elektrotechn. Zeitschr. 32. pp. 295–296, March 23, 1911. Extract of Dissertation, Berlin, 1910.)—Discusses Maxwell's criteria, and proposes a winding in successively thicker coils. Experimental results are given. A. D.

682. *Notes on the Tilted Gold-leaf Electrometer.* **G. W. C. Kaye.** (Phys. Soc., Proc. 23. pp. 209–218, April, 1911. Electrician, 66. pp. 940–941, March 24, 1911. Abstract.)—Suggestions are given as to the manipulation of gold-leaf suspensions, suitable insulators for electrometer work, &c.

683. *An Electrical Trevelyan Rocker.* **W. H. Eccles.** (Phys. Soc., Proc. 23. pp. 204–208, April, 1911.)

684. *New Potentiometer.* **K. Feussner.** (Elektrotechn. Zeitschr. 32. pp. 187–190, Feb. 23, and pp. 215–218, March 2, 1911. Communication from the Physikal.-Techn. Reichsanstalt.)—Describes a new form of potentiometer suitable for the accurate measurement of voltages, currents, and resistances of high and of low values. The contact surfaces and all current-carrying parts are inside a metal box and are protected from light, dust, and heat radiation. For full details of the potentiometer the original paper should be consulted. F. E. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

685. *New Method of Chemical Analysis.* **J. J. Thomson.** (Electrician, 67. p. 19, April 14, 1911. Abstract of discourse delivered before the Royal Inst., April 7, 1911. Engineering, 91. pp. 489–490, April 14, 1911.)—It is now suggested that the method of photographing the positive rays as described in a previous paper [see Abstract No. 658 (1911)] should be employed in the analysis of gases. This is done by ascertaining from the deflections of the positive rays with magnetic and electric fields the atomic weights of the substances present. This method has the advantage over others, such as spectroscopy, owing to the fact that it is possible to work with quantities as small as 0·08 mgm., while, again, the purity of the substance used is of no consequence, since any foreign substance would be indicated by a separate curve. The records being made during the actual period when changes are occurring in the gas, the existence of such groups as $CH+$, CH_2+, CH_3+ has now been demonstrated. Some curves obtained are peculiar; thus, one is in such a position as to indicate the presence of atoms of mercury with three positive charges, while another would seem to belong to atoms of carbon with four positive charges. It would seem that there are in these positive rays quite a large variety of atomic and molecular aggregations carrying one or several charges, or uncharged. Thus oxygen yields nine such modifications. This would account for the different kinds of spectra emitted by the same substance under different conditions. The rays on the negative side are always produced by substances in the atomic condition, which is explained by the fact that the atom possesses greater freedom of movement than the molecule. It is proposed to study the transformation-products of radium by this method. A. E. G.

686. *Periodic Relations of the Elements.* **B. K. Emerson.** (Amer. Chem. Journ. 45. pp. 160–210, Feb., 1911.)—The author arranges the elements in the order of their atomic weights along a spiral which consists of four successive systems of loops with increasing diams. The apex of the spiral is occupied by "ether," coronium, hydrogen, "nebulium," "proto-fluorine," and helium compose the first and smallest loop, coronium and helium being on the same generator. Then come double loops with twice the diam. and twice the number of divisions each. They are Li, Ge, B, C, N, O, F, and Ne; and Na, Mg, Al, Si, P, S, Cl, and Ar respectively. This group is followed by four loops of twice the diam. of the last and twice the number of elements, RaEm ("niton") being at the end of the fourth loop and the beginning of the next group of loops of still larger diam. The elements hitherto discovered which fit into this larger loop are Ra, Io, Th, and Ur, but there are gaps between niton and Ra, and between Th and Ur respectively. The author deals at length with a number of physical and chemical properties of the elements, with special regard to their cosmic and terrestrial distribution. E. E. F.

687. *The Electron Conception of Valence.* **K. G. Falk** and **J. M. Nelson.** (Amer. Chem. Soc., Journ. 32. pp. 1637–1654, Dec., 1910.)—The author has attempted to apply the hypothesis of J. J. Thomson, according to which the linkages between atoms in a compound are caused by the transfer of corpuscles, to a number of classes of compounds, both organic and inorganic. The most interesting result obtained is that all cases of isomerism connected with the presence of a double bond, whether between like or unlike atoms, have been referred to the direction of the valencies of the double bond, instead of to spacial configurations as heretofore. The existence of certain isomers and the explanation of some hitherto unexplained reactions have also been referred to the direction of valencies. A. F.

688. *Liberation of Gases from Tubes of Glass, Porcelain, Silica.* **M. Guichard.** (Comptes Rendus, 152. pp. 876–879, March 27, 1911.)—In his researches on gases retained by metals, the author finds that considerable quantities of gases may be occluded by the walls of the tubes, in which the metals are heated, and he estimates the amount of gas with the aid of McLeod gauges. Jena glass, merely exposed to very low pressure, yielded very little gas in the cold, more (about 0·5 mgm. per 100 cm.^{2} of surface) at 600° C., and it reabsorbed about one-third of this gas again from air in the course of a few hours. Three specimens of glazed porcelain differed much as to their gas-contents. An apparatus of 429 cm.^{3} and 117 cm.^{2} surface yielded altogether, heated in stages up to 1170° C., 2·1 cm.^{3} of gas (0·3CO_2, 0·3O, 1·5N); at 1100° the glazing looked frothy. The rate of liberation diminished when the heating was continued for hours and was great when the initial pressure was small, below 1 mm. The cracks of tubes of opaque silica are full of gas; a tube of 419 cm.^{3}, surface 130 cm.^{2}, heated for 12 hours to 800° C., and then for 2¼ hours to 1040° C., gave 2·45 cm.^{3} of gas, half CO and half hydrogen. H. B.

689. *The Separation of Oxygen by Cold.* **J. Swinburne.** (Faraday Soc. Trans. 6. pp. 212–224; Discussion, p. 224, Feb., 1911. Chem. News, 103. pp. 38–42, Jan. 27, and pp. 50–51, Feb. 3, 1911.)—Although the separation of atmospheric oxygen and nitrogen has arisen out of the liquefaction of air, the two problems are not the same. Imagining the operations to be carried out in thermally-insulated closed vessels, the author shows that, in the liquefaction process, the expanding gas might work an engine, but that the addition of such a device would not be an advantage in the separation of the gases. In this he differs from G. Claude. Even the Linde process does not necessarily involve irreversible expansion through a nozzle. Two unmixed gases have a certain availability of energy which is lost on mixing them; but it should be possible to effect the separation of the gases under conditions promising a cheap supply of oxygen. H. B.

690. *A New Theory of the Phenomenon of Allotropy.* **A. Smits.** (Konink. Akad. Wetensch. Amsterdam, Proc. 12. pp. 763–774, April 28, 1910.)—The liquid phases of tautomeric substances consist of two kinds of molecules, and the inner equilibrium existing in the liquid can extend into the solid phase. On rapid cooling, this presence of two kinds of molecules leads to a binary behaviour because the equilibrium cannot keep pace with the change of temperature and solidification occurs at a temperature differing from the unary stable melting-point. The conditions of equilibrium for two modifications only partially miscible in the solid (heterogeneous allotropy) and for modifications completely miscible (homogeneous allotropy) are discussed and the theory is confirmed by experiments on mercuric iodide, the red β modification of which is converted into the yellow α variety at 127° C. on

heating. By rapid cooling the two varieties can be obtained side by side. The melting-point of pure rhombic sulphur is 112·8° C., the unary melting-point being 110·6°C. Starting from rhombic sulphur and allowing equilibrium to set in at 90° C., a melting-point at 110·9° C. is obtained; if equilibrium occurs at 65° C., the subsequent melting-point is 111·4° C, this pointing to the existence of two kinds of molecules. The theory offers a ready explanation of the phenomena of undercooling and superheating, and, in fact, of all the phenomena of retardation such as occur in the Fe-C and other systems during rapid cooling. F. C. A. H. L.

691. *Confirmation of the New Theory of Allotropy.* **A. Smits** and **H. L. de Leeuw.** (Konink. Akad. Wetensch. Amsterdam, Proc. **13.** pp. 822–829, Feb. 28, 1911.)—The new theory of allotropy [see preceding Abstract] has been confirmed by observations on the melting-point of phosphorus, which under rapid cooling and heating showed a similar behaviour to that observed in the case of sulphur. Special precautions were taken to prepare pure phosphorus by repeated distillation and fractional crystallisation *in vacuo*; the pure product was run into an evacuated vessel so that it surrounded a delicate resistance-thermometer. It melted at 44° C. with a range of only 0·02°, but after immersing in boiling water for some time and then transferring to a cold bath at 15° C. supercooling took place, but in one case on solidification the temperature rose to 46° C., showing that, under very rapid cooling, phosphorus is supercooled above 44° C. Subsequent heating in a bath at 50° C. showed a melting range of 0·18° C. These phenomena are accounted for by assuming the presence of two kinds of molecules, and an equilibrium diagram is drawn and discussed on these lines. The existence of three modifications of phosphorus, white, red, and violet (stable below 460° C.), could be accounted for by assuming the presence of three kinds of molecules, but a more plausible explanation lies in assuming a discontinuity in the series of mixed crystals. Mercury was also examined, but, no matter how slowly or rapidly cooled, always showed a unary melting-point in agreement with the existence of only one known variety of this substance.

F. C. A. H. L.

692. *Investigations on Bearing-metals.* **E. Heyn** and **O. Bauer.** (Königl. Materialprüfungsamt, Mitt. **29.** 2. pp. 68–110, 1911.)—Chemical analyses were made of the raw materials used for the bearings, of the newly made bearings, of bearings melted up once without addition of new material, and of the bearings after melting 5 times repeated. By microphotographs and mechanical tests, investigations were made of the effect on structure and composition of the method of casting (crucible or sand casting), of repeated remelting without addition of new material, and of the addition of arsenic to the metal. The tests show that by regulating the rate of cooling, a bronze poor in tin, and therefore cheap, may be obtained, having mechanical properties as good as those of a tin-rich bronze which has not been cooled to the best advantage. Quicker cooling from temperatures above 782° C. raises, in general, the hardness, malleability, and tensile strength. Consequently crucible castings of the dimensions used in the tests showed higher strengths than sand castings. Moreover, the size of cross-section must exert an influence on the strengths, since cooling is slower with a larger cross-section than with a smaller. This effect is brought out strongly in sand castings. The effect in crucible castings is not so evident within the limits of these tests, since it is overshadowed by the effect of the rapid cooling in the iron moulds. Sand castings are found to be more porous than crucible castings. Remelting has practically no effect on the chemical composition of metal free from zinc. Nevertheless some chemical changes may be made through the oxidation of the tin. The oxide of tin does not force its way to the surface, but remains mixed in the metal. Microscopic examination shows that oxidation of the tin does actually take place after 5 times remelting. Repeated melting has little effect on the hardness and compressive strength, but the resistance to tearing and the elastic strength, as well as strength to resist shock, are diminished. The effect of As on the temperatures of crystallisation is only noticeable when the metal is rich in As, the temperatures being lowered. Less than 1·52 per cent. of As has no appreciable effect on the moulding properties, nor on the structure; As raises the hardness. The ultimate strength is slightly lowered and the elastic limit raised. The elastic extensibility is diminished after 0·8 per cent. is exceeded. Resistance to hammering increases with increase of As, the effect being first evident when 0·65 per cent. of As is present. The higher proportions of As increase the crushing strength but reduce the reduction of length. C. A. M. S.

693. *Physico-chemical Studies on Lead.* I. **E. Cohen** and **K. Inouye.** (Zeitschr. Phys. Chem. 74. 2. pp. 202–206, 1910.)—Experiments on the electrolytic crystallisation of lead made by Lehmann, indicate the existence of two crystalline varieties, one obtained under normal conditions in the form of octahedra, and the other in the form of feathery leaves apparently belonging to the monoclinic system. Such crystals are obtained by electrolysing dilute lead acetate solutions with a high current-density. The authors have prepared the two forms of crystals, and, by determining the e.m.f. of one against the other and comparing this value with the e.m.f.'s generated by two samples of the same crystals, have shown that they cannot be regarded as allotropic modifications. F. C. A. H. L.

694. *Lead-Tin-Antimony Alloys.* **R. Loebe.** (Metallurgie, 8. pp. 7–15, Jan. 8, and pp. 33–49, Jan. 22, 1911.)—The compositions of the more important of these alloys used technically as bearing- and type-metals are tabulated. The binary systems Pb-Sn, Sb-Pb, Sn-Sb, are dealt with at some length, and for the sake of simplicity the author assumes that the constituents of the first two series are immiscible in the solid, while further work on the Sn-Sb series indicates the existence of three series of solid solutions. Passing on to the general consideration of ternary systems with particular reference to the type in which two of the components form solid solutions between themselves but form neither solid solutions nor compounds with the third component, of which type the series under consideration is an example, the author shows that the equilibrium diagram of a ternary system is always a triangular prism whose sides are formed by the equilibrium diagrams of the constituent binary systems. Upwards of 200 alloys whose compositions lie along 11 oblique sections and one horizontal section parallel to the Sb-Pb side of the concentration triangle, were examined thermally and the results confirmed by microscopic examination. The space model, constructed from the thermal data, shows four liquidus surfaces, one falling from the melting-point of Pb towards the Sn-Sb side, and the other three falling from the Sn-Sb side and corresponding to the three series of solid solutions. A gully runs from the Pb-Sb eutectic point almost horizontal at the beginning and then gradually falling to the Pb-Sn eutectic point. Corresponding to the existence of the two saturated solid solutions in the Sb-Sn series there

are two ternary eutectic points, at 245° and 191° C. respectively. In the solid the rate of diffusion of the solid solutions lagged so much behind the normal rate of cooling that the determination of the solidus and the conditions of equilibrium in the solid was made very difficult. A further difficulty was occasioned by segregation owing to the wide difference in the sp. gr. of the various constituents. Practically the whole of the technical alloys are to be found in the field representing the separation of the Sb-rich Sb-Sn solid solution from the liquid. From general considerations it appears that the ternary system behaves like the binary Sb-Sn system, the lead merely acting as a solvent. F. C. A. H. L.

695. *The Ternary System: Lead-Cadmium-Mercury.* **E. Jänecke.** (Zeitschr. Phys. Chem. 73. 3. pp. 328–342, 1910.)—The general considerations affecting the conditions of equilibrium in a three-component system containing a ternary transition are discussed in detail and the principles applied to the data already obtained for the above system [see Abstract No. 303 (1908)]. A complete diagram of solidification is given, showing the isotherms for every 10°, and it appears that only three phases separate from the liquid, of which two are solid solutions containing very little lead. The results are confirmed by microscopic examination of a number of specimens. F. C. A. H. L.

696. *The Crystallography of the Iron-Carbon System.* **A. Kroll, Jr.** (Iron and Steel Inst., Journ. 1. pp. 304–385; Correspondence, pp. 386–402, 1910.)—The following are the chief points in the author's summary of conclusions: The polyhedral structure of β- and γ-ferrite has been shown for the first time by heat-tinting, the allotropic theory of Osmond being thereby confirmed. The progressive growth of the martensitic austenite bodies in α and β iron, accompanied by their modification into, and deposition as, γ iron, was demonstrated by heat-tinting. Similarly, the continued growth of the same polyhedra of martensite into the cementite—accompanied by powerful transformation phenomena in the latter—was determined; and from this the existence of a solution-carbide, crystallising according to the regular system, was deduced. Quenching experiments enabled pseudomorphs of this transformed and deposited cementite to be identified, these occurring as elongated cubes, in contrast to the hexagonal crystalline form of the cementite. Grounds were discovered for the assumption that the regular solution-carbide strives after saturation with γ iron, thus forming the constituent troostite (the *x* constituent). L. H. W.

697. *Stable Iron-Carbon System. I. Curve of Solubility of Elementary Carbon in Solid Iron.* **R. Ruer** and **N. Iljin.** (Metallurgie, 8. pp. 97–101, Feb. 22, 1911.)—The carbon of five samples of a pig-iron containing 3·75 per cent. C, 0·21 Mn, 0·05 Si, 0·006 S, and 0·01 per cent. P, was increased to 4–4½ per cent., of which below 0·5 per cent. was in the combined form, by fusion with sugar charcoal and subsequent slow cooling *in vacuo*. Small specimens were heated to temperatures ranging from 600–1120° C. for six hours and then quenched in water. Up to 700° C. there was no increase in the combined carbon, but at 800° C. the combined carbon had increased to 75 per cent., at 900° C. to 0·84 per cent., at 1000° C. to 0·99 per cent., and at 1100° C. to 1·24 per cent., and these figures are plotted as representing the lower limit of the solubility of free carbon in iron. With the object of determining the upper limit of solubility small specimens were heated to 1100° C. and slowly cooled

to various temperatures which were maintained for some time, after which the specimens were quenched out. Deposition of temper-carbon does not take place above 800° C., but does occur below this temperature and continues down to 400° C. The degree of separation depends to some extent on the time of heating between 800° and 1100° C., this being attributed to the formation of "centres of crystallisation" between these temperature intervals. The formation of temper-carbon can be diminished either by rapid cooling to 800° C. or from 800° C. to ordinary temperatures, the first having the effect of hindering the formation of centres of crystallisation and the second of hindering their growth. F. C. A. H. L.

698. *Theory of Hardening Carbon-Steels.* **C. A. Edwards.** (Iron and Steel Inst., Journ. 2. pp. 147–165; Discussion and Communications, pp. 165–196, 1910. Engineering, 90. pp. 548–551, Oct. 14, 1910. Mech. Eng. 26. pp. 713–718, Dec. 2, 1910.)—The author has examined the data of this subject in the light of physico-chemical laws with the object of bringing into line the views of the "carbonist" and "allotropic" schools of thought, and has supported his contentions by means of photomicrographs. β iron cannot exist in steels containing over 0·45 per cent. carbon, in which the γ iron must pass directly into α iron in strict accordance with the phase-rule of equilibrium. This critical point differs, therefore, from the Ar_3 point of pure iron, and the β-iron theory would appear to be unable to account for the hardness of quenched steels. The result of quenching is to retain the carbon in the form of a solid solution in γ iron, for which purpose considerable force is necessary, and is probably supplied by the force existing owing to the sudden contraction of the outer shell; and it is this mechanical pressure, combined with the solution pressure, which accounts for the hardness of quenched steels. There does not appear to be any constitutional difference between austenite and martensite, the apparent difference being due to the mechanical pressure causing the twinning of the γ solid-solution crystals. F. C. A. H. L.

699. *Case-hardening of Steel with Special Reference to the Action of Nitrogen.* **J. Kirner.** (Metallurgie, 8. pp. 72–77, Feb. 8, 1911.)—A case-hardening mixture containing, in addition to carbon, sodium chloride 41 per cent., total nitrogen 9, sulphur 0·5, and insoluble residue 18 per cent. (consisting of Fe_2O_3, Al_2O_3, and CaO) was found to give very irregular results, and accordingly its action on a mild steel containing 0·1 per cent. C and 0·48 per cent. Mn was compared with that of freshly charred leather and a nitrogen-free mixture prepared from charcoal and alkali carbonates. Bars of the steel were case-hardened at 700°, 900°, and 1000° C. for 4 hours in each of the mixtures, the depth of carbonising at the various temperatures being 0·15 mm. at 700°, 1·0 mm. at 900°, and 1·5 mm. at 1000° C. Turnings to these depths were afterwards machined off and analysed. No change took place in the S-, P-, Si-, and Mn-contents, but with the nitrogenous mixtures the nitrogen-content of the outer layers rises up to 0·6 per cent. at the low temperatures, but decreases to the normal amount at 1000° C. With the nitrogenous mixtures, the carbonising action as determined by the contents of the outer layers only, increases rapidly above 900° C., while with the nitrogen-free mixture a steadily increasing carbonising action with the temperature is observed, and even above 900° its action is always more intense than that of the other two mixtures. Under the microscope the specimens cased with the nitrogenous material exhibits a new structural constituent which is coloured brownish-yellow by picric acid. The constituent is very similar in appearance to the martensitic structure of well-hardened tool-steel, and is attributed to the presence of a solid solution or compound of nitrogen in iron, and has been called "Flavite." After hardening, the structure disappears, so that flavite would appear to dissolve in martensite. The experiments throw no light on the cause of the irregularities observed between 600° and 850° C. F. C. A. H. L.

700. *Influence of Silicon on Pure Cast-iron.* **A. Hague** and **T. Turner.** (Iron and Steel Inst., Journ. 2. pp. 72–93; Discussion and Communications, pp. 94–104, 1910. Engineering, 90. pp. 841–844, Dec. 16, 1910. Metallurgie, 8. pp. 118–124, Feb. 22, 1911. Extract.)—Seventeen samples of cast iron containing about 2·75 per cent. C, traces of P and S, and only 0·05 per cent. Mn, with Si varying from 0·03 to 3·0 per cent., have been prepared and examined thermally, microscopically, and for volume-changes. The thermal results show three arrests, the upper one, corresponding to the beginning of solidification, varying irregularly between 1195° and 1247° C., the second gradually increasing with the Si-content from 1136° to 1161° C., and the third one, corresponding to the pearlite change-point, gradually increasing from 700° to 795° C. Pure washed cast-iron contracts uniformly during and after solidification, the addition of Si introducing an expansion on solidification and another at the pearlite point. The first expansion is probably bound up with the formation of a complex solid solution. Up to 1 per cent. Si the expansions are fairly uniform, but at 1·19 per cent. Si graphite appears and causes a marked increase in the first expansion, while further Si results in the extinction of the expansion at the pearlite point. The microstructures of the alloys show the effect of Si in changing the character of the iron from white to grey. The effect of adding 0·5 per cent. Mn to an alloy containing 3 per cent. Si is to diminish the primary expansion and increase the second expansion, the total remaining about the same. Up to 1 per cent. Si the hardness is increased; between 1 and 2 per cent. a sudden decrease in hardness occurs, while beyond this content a gradual increase occurs. F. C. A. H. L.

701. *Influence of Sudden Temperature-changes on Mild Steel.* **B. Zschokke.** (Rev. de Métallurgie, 7. p. 165, 1910. Metallurgie, 8. pp. 87–92, Feb. 8, 1911.) —A mild-steel tank used for the preparation of concentrated caustic soda solution showed after seven years' use, the development of cracks up to 400 mm. long in the four corners near the rivets. The cracks showed no regular orientation, but were surrounded by narrow rust zones, whereas the rest of the plates was coloured a bluish grey. Experiments made proved that caustic soda has a protective rather than a corrosive action on mild steel, so that the cracks could not be attributed to this cause, and it would appear that they were due to strains set up in the plates by the mechanical and thermal treatment, aided by variations in the quality of the steel. Mechanical tests of the material were uniformly good, but impact tests gave low values, probably due to the existence of the cracks. Specimens of material of similar composition in the form of plates 40 × 40 × 8 mm. were highly polished and subjected to sudden changes of temperature by quenching some from temperatures up to 840° C. and by pouring molten lead on to others, and though some of the quenched specimens revealed a network of quenching lines, none of them developed cracks comparable with those produced in the tank. In the tank, however, the stresses cannot be dissipated in all directions so quickly as in the small specimens, and it is quite likely that local strains are set up and intensified by the repeated changes of temperature over many years. F. C. A. H. L.

702. *Surface Action of Glass in Vapour-Density Determinations.* **K. Drucker** and **G. Ullmann.** (Zeitschr. Phys. Chem. 74. 5. pp. 567–611, 1910.)—The authors have made a very complete and careful determination of the error caused in vapour-density measurements by condensation upon the glass surfaces. The apparatus employed consisted of a modified form of the Hofmann vapour-density apparatus and was fitted with an arrangement for breaking the small tubes which contained the liquid under investigation. The measuring tube contained glass wool, thereby increasing the active surface of the glass. The liquids used were carefully purified and distilled *in vacuo* into the small tubes which were subsequently used in the determinations. The chief results of the investigation are as follows: (1) The vapours of benzene, ether, chloroform, and alcohol are slightly, but still to a measurable extent, condensed upon the relatively small surface of the measuring tube. The error so caused can be neglected in ordinary measurements. (2) The vapour of acetic acid is condensed to such an extent that even in measurements of ordinary accuracy a correction must be introduced. (3) The complexity constant of the vapour of acetic acid, calculated from the corrected vapour density, shows a much less dependence upon the temperature than that which was obtained in the experiments of Ramsay and Steele. Similarly the product of this constant and the saturation pressure varies only slightly with the temperature. (4) Saturated acetic acid vapour exhibits no minimum of density with change of temperature, but like all other vapours becomes denser with rising temperature. The experiments of Ramsay and Young, upon which the assumption of a minimum is founded, are vitiated by the fact that they contain the error due to adsorption, which is corrected for above. (5) The experiments of Ramsay and Steele contain the error due to incorrect determination of the temperature of the mercury column in the measuring tube. F. J. B.

703. *Dissociation of Electrolytes in Non-aqueous Solvents as determined by the Conductivity and Boiling-point Methods.* **H. R. Kreider** and **H. C. Jones.** (Amer. Chem. Journ. 45. pp. 282–324, March, 1911.)—The authors have measured the conductivity of various salts in methyl and ethyl alcohols at very high dilutions and in mixtures of the alcohols with water. The limiting value μ_∞ of the molecular conductivity was reached at dilutions ranging from 3200 to 51,200 litres. A constant ratio was found between the values of μ_∞ for several binary electrolytes in the two solvents. The following table shows the dissociation of certain salts in decinormal solutions as determined by the two methods, the values by the conductivity method being higher throughout.

Salt.	Solvent.	Dissociation from Conductivity Method.	Dissociation from Boiling-point Method.
KI	Methyl alcohol	65 per cent.	49 per cent.
KI	Ethyl ,,	49 ,,	26 ,,
NaI	Methyl ,,	75 ,,	61 ,,
NH_4Br	Methyl ,,	71 ,,	47 ,,
NH_4Br	Ethyl ,,	40 ,,	20 ,,

T. M. L.

704. *Primary Gas Cells at High Temperatures.* **R. Beutner.** (Zeitschr. Elektrochem. 17. pp. 91–98, Feb. 15, 1911.)—The cells are of the type;

Oxygen | M_O | fused electrolyte | M_H | hydrogen ; M_O is a metal permeable for oxygen, M_H for hydrogen ; the electrolyte should be impermeable for both gases. The electrodes are tubes of Pt, 6 mm. in diam., dipping 1 mm. into the electrolyte, either (KF + NaCl) or (LiCl + NaCl), and closed below by a disc of Pd, 0·1 mm. in thickness. The two electrodes are exactly alike and give no current as such ; the one was charged with air, the other with H ; when the H was replaced by CO_2, the e.m.f. vanished. The cells are, therefore, hydrogen-oxygen cells ; but the full e.m.f. was not attained, because the permeability of the Pd for oxygen was imperfect, and the electrolyte dissolved oxygen, which led to strong polarisation. The max. values observed, with resistances ranging from 0 to ∞ and temperatures between 680 and 780° C., were 0·95 volt and 1·4 amps./cm.^{2}. In other experiments the Pt tube was replaced by a capillary of nickel ; the oxygen electrode became oxidised, and the e.m.f. did not rise above 0·22 volt, temperature 680 to 790° C. ; in sodium acetate (temperature 310° C.) only very weak, unsteady currents were obtained. **H. B.**

705. *Electromotive Force in an Electrolyte due to Gravitation.* **P. Bary.** (Journ. de Physique, 9. pp. 901–905, Nov., 1910. Paper read before the Soc. franç. de Physique, May 6, 1910.)—The author shows that if there is a difference in level between the two electrodes in an electrolytic cell, such as Cu—$CuSO_4$—Cu, the e.m.f. produced is given by the expression—

$$e = \frac{Pl}{947} \cdot \frac{d - d'}{d} \cdot 10^{-6},$$

where P is the electrochemical equivalent of the metal, l the difference in level of the electrodes, d the density of the metal ions, d' the density of the solution, and e the e.m.f. For the cells Cu—$CuSO_4$—Cu and Ag—$AgNO_3$—Ag the e.m.f.'s thus produced are calculated to be 3×10^{-6} and 1×10^{-5} volt respectively, assuming that d' is in each case = 1·1, and that d is the same as the density of the metal. Actual experiments with the first cell gave values of 0·017–0·024 millivolt, that is, six to eight times greater than required by the theory. The action of gravity may be replaced by centrifugal force, and in this case also the experimental values are greater than the theoretical. No explanation can be given of the discrepancies, since it is probable that the assumption that d is the same as the density of the metal diminishes the difference between the experimental and theoretical values. **T. S. P.**

706. *Rapid Electro-analysis with Tap Funnels and Stationary Electrodes.* **T. S. Price and A. W. T. Hyde.** (Soc. Chem. Ind., Journ. 30. pp. 391–396 ; Discussion, p. 396, April 15, 1911.)—The tap-funnel of Price and T. C. Humphreys [see Abstracts Nos. 756 and 757 (1909) and 1056 (1910)] has been adapted to stationary electrodes. As some electrolyte remained in the neck of the ordinary tap-funnel and escaped electrolysis, the funnel has been provided with a two-way tap so that air-bubbles can be blown through the solution which is thereby stirred. Particulars are given of the determination of copper, with special regard to Frary and Peterson, to Blasdale and Cruess, and to Stoddart, of nickel and of zinc. Three types of kathodes were used, all sand-blasted, a stationary cylinder of gauze, a double disc of gauze (after Hildebrand), and a rotating gauze kathode of F. M. Perkin (for comparison). The copper sulphate solution should contain 1 or 2 cm.^{3} of nitric acid per 70 cm.^{3} of electrolyte. Zinc may be deposited from sodium sulphate, sodium acetate, and acetic acid (0·5 cm.^{3} of the latter per 70 cm.^{3} of electrolyte) ; in alkaline solutions (ammonium sulphate and ammonia) zinc oxide or hydroxide is also deposited, as Spear, Wells, and Dyer had found. Nickel was satisfactorily deposited from nickel-ammonium sulphate. Rotating electrodes appear on the whole preferable. The paper was discussed by **C. Leigh, W. E. Hughes, and H. W. Brownsdon.** H. B.

707. *Character of Silver Deposits from Various Electrolytes.* **J. S. Hughes and J. R. Withrow.** (Amer. Chem. Soc., Journ. 32. pp. 1571–1576, Dec., 1910.)—In the electrodeposition of silver from nitric acid solution spongy deposits are obtained with voltages of more than 1·4 volts, and crystalline deposits with less than 1·4 volts. If the potential is varied, at about 1·8 volts the colour of the deposit changes sharply from white to black, or *vice versâ*. In order to study the black deposit a heavy one was secured. The voltage was then reduced to 1·2 volts, thereby causing the usual flash of white metallic silver, which covered everything that was black just before. The current was then reversed, and the double layer deposit, which was now the anode, almost completely dissolved off without changing from the colour of the later deposit of silver. Thus the layer of black silver which was first deposited on the kathode never became visible on what was now the anode, which seems to indicate that the white flash is a real bleaching or change in colour of the black silver itself. With other electrolytes also (ammonium hydroxide and sulphate; ammonium hydroxide and phosphate; ammonium hydroxide and sodium pyrophosphate; ammonium acetate and nitric acid), 1·4 volts forms the limit between spongy and crystalline deposits, whereas with a cyanide electrolyte this point is much higher. A similar limit of 1·4 volts was obtained with the following electrolytes, which are different from those ordinarily used: (1) Sulphuric acid; (2) sulphuric acid and glycerine; (3) ammonium thiocyanate; (4) sodium and ammonium hydroxides; (5) ammonium hydroxide and perchloric acid; (6) potassium fluoride; (7) hydrogen silico-fluoride. With potassium thiocyanate there was an anodic deposition of sulphur, whereas with (1), (5), and (6) silver oxide was deposited on the anode. T. S. P.

708. *Behaviour of Copper Anodes in Chloride Solutions.* **S. Dushman.** (Journ. Phys. Chem. 14. pp. 885–908, Dec., 1910.)—Preliminary experiments having shown that it is possible to make copper dissolve anodically in hydrochloric acid, either wholly as a cupric or wholly as a cuprous salt, or as a mixture of both in any desired proportions, by varying the concentration of the acid, current density, rate of stirring and rate of circulation of the electrolyte, it was assumed that the equilibrium $Cu^{\cdot\cdot} + Cu \rightleftharpoons 2Cu^{\cdot}$ exists at the anode. Experiments were therefore undertaken to test this assumption quantitatively. The concentrations of the cuprous and cupric salts at the electrode were very different from those obtaining in the solution, being sometimes twenty times as great, and had to be calculated from the latter by allowing for diffusion. Special methods were devised for determining the ratios of the thickness of the diffusion film to the diffusion constants of cuprous and cupric salts respectively. Electrolyses were carried out in which the concentration of the hydrochloric acid varied from $4{\cdot}65 \times 10^{-3}$ to $16{\cdot}15 \times 10^{-3}$ times normal, the current from 0·018 to 0·051 amp., the anode area from 18 to 47 cm.², and the rate of circulation of the electrolyte through the cell from 0·242 to 2·861 c.cm. per sec. It was found that the fraction of copper dissolved as cuprous salt varied from 25 to 74 per cent. From the values of the concentrations at the electrode as calculated for all these experi-

ments, values of the "constant," $k = [\mathrm{Cu}^{\cdot\cdot}]/[\mathrm{Cu}^{\cdot}]^2$, were determined, and were found to be in good agreement with the number deduced from the equilibrium experiments of Bodländer and Storbeck, in which copper powder and cuprous chloride were shaken with solutions of potassium chloride. The fraction of copper dissolved as cuprous salt at a rotating anode in hydrochloric acid, with varying conditions of concentration of acid, current density, rate of rotation and rate of circulation of the electrolyte, was calculated from this theory and found to be in good accord with the experimental results. T. S. P.

709. *Ebullition of Electrolytes during the Passage of an Electric Current.* **R. Cegielskij.** (Deutsch. Phys. Gesell., Verh. 13. 6. pp. 227–248, March 30, 1911.)—The passage of a current through boiling electrolytes, which are at the same time heated by a constant flame, is accompanied by considerable temperature variations, which depend partly on the current strength and partly on the nature of the electrolyte. The author develops a relation between the total heat developed in the system, the current strength and the temperature, which is in qualitative agreement with the experimental results. The electrolytes can be divided into two classes: (*a*) With electrolytes which liberate hydrogen and oxygen on the passage of a direct current—for example, dilute H_2SO_4, HNO_3, Na_2SO_4—the temperature first falls with increase in the current strength—it may even fall below the boiling-point of water—and then rises, in some cases above the true boiling-point of the solution. In the same class are included other electrolytes, *e.g.*, NaCl, which evolve gases on the passage of a current, but the phenomena mentioned are not so well defined. (*b*) With electrolytes where no gas is evolved and the total heat-effect due to chemical action is zero, there is a continual rise in temperature, to far above that of the boiling-point of the solution, with increase in the current; such electrolytes are $CuSO_4$ and $ZnSO_4$. This behaviour can be explained by the assumption that considerable hindrances to ebullition occur during the passage of the current; it is noteworthy that in spite of these hindrances the liquid wells up considerably during the passage of the current. With alternating currents the electrolytes of class (*b*) show essentially the same behaviour as with the direct current, whereas those of class (*a*) are markedly different in behaviour. When an electrolyte has been heated to the boiling-point and the flame then taken away, the rate of cooling without the passage of a direct current is slower or quicker than when current is passed according as the electrolyte belongs to group (*a*) or (*b*); this behaviour is in agreement with the theory put forward. When alternating currents are used both groups of electrolytes cool slower than when no current is passed, unless the current is very weak, when the rate of cooling is the same. T. S. P.

710. *Transference Experiments with Thallous Sulphate and Lead Nitrate.* **K. G. Falk.** (Amer. Chem. Soc., Journ. 32. pp. 1555–1571, Dec., 1910. Contribution from the Research Lab. of the Mass. Inst. of Technology, No. 60.)—Noyes has pointed out that the change of the transference number of tri-ionic salts with the concentration might be expected to throw light on the question as to whether intermediate ions, such as KSO_4' in the case of potassium sulphate or $BaNO_3'$ in the case of barium nitrate, existed in appreciable quantities in solutions of such salts. In this paper transference experiments with 0·08- and 0·1-normal solutions of thallous sulphate and lead nitrate at 25° are described, a special apparatus being used. The kathion transference numbers found for the thallous salt are 0·479 at 0·08, and 0·0476 at 0·1 normal, those for the lead salt being 0·487 at both concentrations, the max. error being about 0·5 per cent. The transference number at zero concentration as calculated from Kohlrausch's extrapolated values of the equivalent conductivities of the separate ions is 0·489 for thallous sulphate and 0·508 for lead nitrate, these values thus being 2·5 to 3·2 per cent. higher than those found by direct measurement. It is uncertain whether this change of the transference number with the concentration is real; if it is so, in the case of thallous sulphate it lies in the direction required by the presence of the intermediate ion, TlSO'_4, whereas in the case of lead nitrate the intermediate ion, $\mathrm{PbNO}^{\cdot}_3$, would probably cause a change in the opposite direction. From the results of these and other accurate transference values for tri-ionic salts, it is concluded that either the intermediate ion is not formed to any considerable extent by the dissociation of such salts up to concentrations of 0·1–0·2 normal, or, if formed, its equivalent conductivity has a definite value of such magnitude that the transference number is independent of its concentration. T. S. P.

REFERENCES.

711. *Electron Theory of Metallic Solutions.* **A. L. Bernoulli.** (Deutsch. Phys. Gesell., Verh. 13. 5. pp. 213–218, March 15, 1911.)—Discusses the law of Babo with respect to dilute solid metallic solutions (or *Mischkristalle*). [See Abstract No. 135 (1911).] E. H. B.

712. *Proof of the Movement of Dissolved Molecules as demanded by the Molecular Kinetic Theory.* **T. Svedberg.** (Zeitschr. Phys. Chem. 74. 6. pp. 738–742, 1910.)—Using Regener's method [see Abstract No. 1700 (1909)] and a solution of polonium chloride as the radio-active substance, the author shows that also in real solutions spontaneous differences in the concentration occur at different times, and to such a degree as is in accordance with the value demanded by the molecular kinetic theory. [Compare Abstracts Nos. 189 and 483 (1910).] T. S. P.

713. *Metallic Structure.* **W. v. Möllendorff.** (Elektrochem. Zeitschr. 17. pp. 274–277, Jan., 1911.)—Four photomicrographs illustrating the structure of copper for conductivity wire at various stages during the deoxidising process are shown. F. C. A. H. L.

714. *Ternary Alloys of Silver, Tin, and Lead.* **N. Parravano.** (Accad. Lincei, Atti, 20. pp. 170–172, Feb. 5, 1911.)—This system is of the same type as that of Cu-Sb-Bi, being also complicated by the existence of a compound of two of the components, viz., Ag_3Sn. A thermo-diagram for the system, including this compound, is given. W. H. Si.

715. *A Thermo-electric Method of Cryoscopy.* **H. H. Dixon.** (Roy. Dublin Soc., Proc. 13. 4. pp. 49–62, April, 1911.)—Gives an account of the arrangements employed in some work on the osmotic pressures of plant juices, a differential thermo-electric device being used for accurate measurements of the freezing-points of small quantities of solutions. L. H. W.

716. *Viscosity and Fluidity of Matter in the Three States of Aggregation and the Molecular Weight of Solids.* **E. C. Bingham.** (Amer. Chem. Journ. 45. pp. 264–281, March, 1911.)—The view expressed by Kuppfer in 1861 that the damping of a wire is a measure of its fluidity is elaborated, and it is suggested that methods of this kind may be used to measure the viscosity, and hence the molecular weight, of solids. T. M. L.